EVALUATION OF SPATIAL RELATIONSHIP OF INFERIOR ALVEOLAR CANAL IN THREE DIFFERENT AGE GROUPS USING CONE BEAM COMPUTED TOMOGRAPHY

DISSERTATION

Submitted to The Tamil Nadu Dr. M.G.R. Medical University in partial fulfillment of the requirement for the degree of

MASTER OF DENTAL SURGERY

BRANCH IX

ORAL MEDICINE AND RADIOLOGY

2013 - 2016

CERTIFICATE

This is to certify that this dissertation titled "**Evaluation of spatial relationship of Inferior alveolar canal in three different age groups using Cone Beam Computed Tomography**" is a bonafide research work done by **Dr. M. Farakath Khan** under our guidance during his Post Graduate study during the period of 2013-2016 under THE TAMIL NADU Dr. M.G.R. MEDICAL UNIVERSITY, CHENNAI, in partial fulfillment for the degree of MASTER OF DENTAL SURGERY IN ORAL MEDICINE AND RADIOLOGY, BRANCH IX. It has not been submitted (partial or full) for the award of any other degree or diploma.

Dr. TATU JOY. E. M.D.S.,
Professor & HOD
Department of Oral Medicine & Radiology
Sree Mookambika Institute of Dental Sciences
Kulasekharam - 629161

Dr. J. EUGENIA SHERUBIN M.D.S
READER
DEPARTMENT OF ORAL MEDICINE AND RADIOLOGY
SREE MOOKAMBIKA INSTITUTE OF DENTAL SCIENCES
KULASEKHARAM. K. K. DIST.

Dr. TATU JOY. E M.D.S

Guide

Professor and HOD

Department of Oral Medicine and Radiology

Sree Mookambika Institute of Dental Sciences,

Kulasekharam

Dr. J. EUGENIA SHERUBIN M.D.S

Co-Guide

Reader, Department of Oral Medicine and Radiology

Department of Oral Medicine and Radiology

Sree Mookambika Institute of Dental Sciences,

Kulasekharam

SREE MOOKAMBIKA INSTITUTE OF DENTAL SCIENCES, KULASEKHARAM

ENDORSEMENT BY THE PRINCIPAL / HEAD OF THE INSTITUTION

This is to certify that this dissertation titled "**Evaluation of spatial relationship of Inferior alveolar canal in three different age groups using Cone Beam Computed Tomography**" is a bonafide research work done by **Dr. M. Farakath Khan** under the guidance of Dr. Tatu Joy. E MDS, Professor and Head, Department of Oral Medicine and Radiology, Sree Mookambika Institute of Dental Sciences, Kulasekharam.

SREE MOOKAMBIKA INSTITUTE OF DENTAL SCIENCES

17/12/15

Dr. Elizabeth koshi MDS
Principal
Sree Mookambika Institute of Dental Sciences
V.P.M. Hospital Complex
Padanilam Kulasekharam-629 161
K.K Dist., Tamilnadu

Dr. Elizabeth Koshi MDS,

PRINCIPAL,

Sree Mookambika Institute of Dental Sciences.

V.P.M Hospital Complex,

Padanilam, Kulasekharam,

KanyaKumari District,

Tamil Nadu - 629 161

ACKNOWLEDGEMENT

I am very grateful to the Almighty God for giving me this wonderful life, leading me through this journey and for giving me almost everything in my life.

I am extremely grateful to my guide, **Dr. Tatu Joy. E MDS**, Head of the Department of Oral Medicine and Radiology, Sree Mookambika Institute of Dental sciences, for the everlasting inspiration, unwavering support along with valuable suggestions for improvement in every aspect during the entire period of my post-graduation.

Words are inadequate to express my deep sense of gratitude and sincere thanks to **Dr. Eugenia Sherubin MDS,** Reader, Department of Oral Medicine and Radiology, Sree Mookambika Institute of Dental sciences, for her incessant encouragement, brilliant advice, and practical approach.

I would like to deeply thank **Dr. Shashi Kiran M, MDS**, Reader, Department of Oral Medicine and Radiology, Sree Mookambika Institute of Dental sciences for his valuable guidance, encouragement, unlimited support and help.

I thank **Dr. Redwin Dhas Manchil MDS,** Senior Lecturer, Sree Mookambika Institute of Dental sciences for his constant encouragement, advice and valuable suggestions.

I would like to acknowledge the help and support given **by Dr. Velayuthan Nair MBBS, MS** Chairman and **Dr. Rema V Nair MBBS, MD, DGO** Director Sree Mookambika Institute of Dental Sciences without which my study would not have been possible. I express my gratitude to Principal **Dr. Elizabeth Koshi MDS** who has been encouraging and supportive.

To my wonderful **father** who I really missed, even though you are not in this life any more you will always be in my heart and soul. Thank you so much for giving me every thing that I have and making me what I am right now.

Words are not sufficient to convey my gratitude to my loving **mother, wife and daughter** for their encouragement, love, great sacrifices and innate confidence without which I wouldn’t have been where I am today. I am eternally grateful to them for all that they have done for me.

I am thankful to Mr**. K. Boopathi** for providing me with his timely statistical analysis involved in this study.

I am extremely thankful to the staffs in the Maxillofacial Diagnostic centre, Ernakulam for their suggestions and help in collection of data for this study.

I gratefully thank and acknowledge my batch mates Dr. Indu Krishna, Dr. Melbia and my fellow post graduates Dr. Vineetha, Dr. Meera, Dr. Aravind, Dr. Hema, Dr. Kartheesan Dr. Lekshmi, and Dr. Divya for their motivation and encouraging words.

CONTENTS

LIST OF ABBREVIATIONS

CT - Computed tomography

CBCT - Cone beam computed tomography

DVT - Dental volumetric tomography

CBVT - Cone beam volumetric tomography

IAC - Inferior alveolar canal

IANC - Inferior alveolar nerve canal

IAN - Inferior alveolar nerve

BCP - Buccal cortical plate

LCP - Lingual cortical plate

Inferior BM - Inferior border mandible

AFH – Anterior facial height

FOV - Field of view

MPR - Multiplanar reformation

MIP - Maximum intensity projection

Min IP - Minimum intensity projection

SSR - Shaded surface rendering

VR - Volume rendering

DICOM - Digital Imaging and Communications in Medicine

OPG - Orthopantomographs

LCBCT - Limited cone-beam computerized tomography

MDCT - Multidetector computed tomography

SSCT - Single slice computed tomography

mA - Milliamperes

kvp - kilovolts peak

ANOVA - Analysis of variance

Tukey HSD - Honest Significant Difference

LIST OF FIGURES

LIST OF TABLES

LIST OF GRAPHS

BACKGROUND :

Conventional two dimensional (2-D) radiographic images, such as intra oral periapical radiographs and panoramic radiographs, are most commonly used to assess the relationship between the inferior dental nerve canal and mandibular posterior teeth. However, three dimensional (3-D) radiographic modalities such as computed tomography (CT) and Cone Beam Computed Tomography (CBCT) provide more accurate information with less distortion compared to the 2-D images. Cone beam computed tomography (CBCT), a relatively new imaging modality in dentistry, produces high-resolution, artifact-free, superimposition-free, undistorted and non-magnified 3D images of the dental and maxillofacial anatomy that can be reformatted in any desired plane for interactive viewing and image manipulation. The radiation dose is significantly less than that of conventional medical grade CT.

AIM:

To evaluate the spatial relationship of Inferior alveolar canal in three different age groups using Cone Beam Computed Tomography

MATERIALS AND METHODS:

The study was done in Maxillofacial Diagnostics, Ernakulam and the Department of Oral Medicine and Radiology, Sree Mookambika Institute of Dental Sciences, Kulasekharam, KanyaKumari district on 90 CBCT images. Study group will comprise of images of 30 patients of age <20, 30 patients of age 20-40, and 30 patients of age 41-65 years. To compare mean values between age groups one way ANOVA is applied, followed by Tukey's HSD post-hoc test for

pair wise comparison of age groups if found significance in one way ANOVA.

RESULTS:

The results of this study showed the course of inferior alveolar canal, the mean distance of IAC from buccal cortical plate, lingual cortical plate, inferior border of mandible and tooth apex for different age groups. The canal was close to BCP in the region of premolars (2.71 mm first premolar) and LCP in the region of molars (2.08 mm mesial root of second molar). The distance from IAC to root apex and inferior border of mandible increased with advancing age in our study. The results correlated well with other studies.

CONCLUSION:

According to the results of this study, an important consideration in presurgical planning is that the position of inferior alveolar canal will not stay constant throughout a person's lifetime. This study indicates that caution needs to be exercised during surgical procedures in the mandibular posterior region. CBCT seems to provide an optimal, 3D imaging modality to help address the complexities in the inferior alveolar canal configuration, with decreased radiation dose than CT.

KEY WORDS:

Inferior alveolar nerve canal, mandible, cone beam computed tomography

The inferior alveolar nerve canal is an important structure, hosting a crucial neurologic innervation and blood supply to the mandibular teeth, lip and chin. It is a vital structure in many dental procedures, including exodontia, dental implant placement and orthognathic surgery. The canals are located in either sides of the mandible and they exit the mandibular bodies at the buccal surfaces through the mental foramen. Anatomical variations occur concerning the location of the mental foramen. [1,2] Mental foramen is usually found more coronal than the mandibular canal. [3,4]

Violation of the mandibular canal or mental foramen can result in injury of the inferior alveolar nerve, Mental nerve, or adjacent blood vessels. This can cause paresthesia (numb feeling), Hypoesthesia (reduced feeling), hyperesthesia (increased sensitivity), dysesthesia (painful sensation), or anesthesia (complete loss of feeling) of the teeth, the lower lip, or surrounding skin and mucosa. [5] It also may result in venous or arterial bleeding.

Treatment planning would mainly depend on the visibility of the IANC and adjacent structures. The visibility of the canal would basically rely on the imaging modality used during treatment planning and the radiographic appearance of the IANC. Imaging modalities that have been used for such treatment planning and localizing of the IANC include periapical radiographs, panoramic radiographs, computed tomography (CT) and Cone Beam Computed Tomography (CBCT). Panoramic radiography and periapical radiography are 2 Dimensional images and this makes them more difficult to interpret. As an example, neither of these 2-D radiographs is helpful for determining the bucco-lingual relations between roots of impacted third molars and the IANC. If occlusal radiographs were used to assist in the visibility of the IANC in the axial plane, mandibular molars and premolars would overlap and obscure the IANC. Intraoral radiographs with vertical shift might help in localization but they are not accurate in giving precise measurements. [6] For many years in such clinical situations where three-dimensional images are needed, a medical CT had been the only choice. The high cost, radiation dose and limited accessibility restricted its use in routine dentistry. In addition, the medical CT images did not completely satisfy the treatment planning needs of the dentist due to the unavailability of dentist-friendly software programs that allow dentists to perform specific dental treatment planning procedures on the images such as IANC tracing and simulation of implant fixture placements. The invention of CBCT, with its substantially lower radiation dose compared to medical CT, lower cost, better accessibility and associated software programs specifically designed for use in dental diagnosis and treatment planning, made the possibility of examining the canal in three dimensions more feasible for dentists. Although the CBCT principle has been in use for almost 2 decades, CBCT machines have not been used in dental practice until 2001. This was due to the development of inexpensive x-ray tubes, high-quality detector systems, powerful personal computers and reduced cost and field of-View CBCT systems becoming commercially available. [7]

CBCT units are based on volumetric tomography, using a 2 dimensional extended digital array providing an area detector. This is combined with a cone shaped x-ray beam. The Cone-beam technique consists of a single 360° scan in which the x-ray source and a reciprocating detector synchronously rotate around the patient's head; the head is stabilized or supported with a head holder or rest. At certain degree intervals, single projection images are acquired (known as "basis" images). These are similar to lateral cephalometric radiographic images, each slightly offset from one another. This series of basis projection images is known as the projection data. Software programs incorporating sophisticated algorithms including back-filtered projection are applied to projection data to generate a 3 dimensional volumetric data set that can be used to provide primary reconstruction images in 3 orthogonal planes (axial, sagittal and coronal). [8]

There are mainly 2 types of x-ray detectors used in CBCT units. [9,10] The first is the image intensifier tube / charge-coupled device combination detector. The second is the flat panel detector that was released by (i-CAT). [11] The flat panel detector consists of a Cesium iodide scintillator applied to a thin film transistor made of amorphous silicon. Images produced by an image intensifier tube/charge-coupled device combination have lower signal to noise ratio than images from a flat panel detector. The field of view (FOV) of a CBCT system or the scan volume represents the dimensions of the area of the patient to be covered by the scan. Its size varies from one CBCT unit to another and its shape might be either cylindrical or spherical. The scan volume depends mainly on the size and shape of the detector, beam projection geometry and the beam collimation. The flexibility in changing the FOV gives the advantage that only the area of interest is exposed to the x-ray beam and avoids unnecessary exposure to other areas. Ability to control the size allows imaging smaller and larger areas of the maxillofacial region. [8] In CBCT units increasing the size of the FOV is usually associated with reduction in the resolution of the image. This is due to the fact that increasing the size of the FOV is inherently associated with an increase in the voxel size since the number of pixels on the detector is fixed. Recently some CBCT units offer the advantage of maintaining resolution of images with increasing size of the FOV. This is basically due to the ability to control the image voxel size in these CBCT units, in a way that the size of the FOV can be increased and the voxel size is adjusted to a small voxel size or in other words they keep the same voxel size in smaller FOV. [12]

CBCT is helpful for clear visualization of the relationships of the root apices to various neighboring anatomic structures such as the mandibular canals and the maxillary sinuses. This would clearly have an impact on the treatment planning and the prognosis of teeth with endodontic pathology. It also has been shown that CBCT depicts the mandibular canal better than panoramic radiography. This is because of the fact that the CBCT images are free of magnification, superimposition of neighboring structures, and other problems inherent to panoramic radiography. [13]

CBCT also was compared with the multislice CT in detecting the mandibular neurovascular canal structures such as bifid mandibular canal, accessory mental and buccal foramina, and results showed consistency between the two modalities. [14]

Cone beam computed tomography (CBCT), a relatively new imaging modality in dentistry, produces high-resolution, superimposition-free, artifact-free, non-magnified and undistorted 3D images of the maxillofacial anatomy that can be reformatted in any desired plane for interactive viewing and image manipulation. The radiation dose is significantly less than that of conventional medical grade CT. In this study, CBCT images were used in plotting the course of the inferior alveolar nerve, its relationship to the roots of mandibular posterior teeth and its distance from the exterior buccal and lingual cortex.

AIM

To evaluate the spatial relationship of Inferior alveolar canal in three different age groups using Cone Beam Computed Tomography.

OBJECTIVES

a) To evaluate the distance of Inferior alveolar canal from the exterior buccal and lingual cortex in the region of mandibular posterior teeth.

b) To evaluate the distance of Inferior alveolar canal from the inferior border of mandible and root apex in the region of mandibular posterior teeth.

Two-dimensional (2D) imaging modalities have been used in dentistry since the first intraoral radiograph was obtained in 1896. Since then, dental imaging techniques have advanced with the introduction of tomography and panoramic imaging. Tomography made it possible to isolate areas of interest within the scope of a radiographic examination, while panoramic imaging utilizes principles of tomography, making it possible to visualize the maxillofacial structures in a single comprehensive image. More recent advances in digital diagnostic imaging have meant lower radiation doses and faster processing times without affecting the diagnostic quality of the intraoral or panoramic images. However, 2D images possess unique inherent limitations (including magnification, distortion, and superimposition) that can make it possible to misrepresent structures.

Cone beam computerized technology (CBCT) introduces a more complex and accurate imaging with 3-dimensional visualization as compared to the routinely used analog and digital radiographs. It is a precise technology for numerous clinical oral maxillofacial indications with added advantage of lower radiation doses than computerized tomography. 3D cone beam technology is commonly referred as CBCT, DVT (dental volumetric tomography), CBVT (Cone beam volumetric tomography) according to different countries and manufactures. The shape of the X ray beam used for imaging is cone shaped/divergent hence the name Cone Beam Computed Tomography.

HISTORICAL BACKGROUND

First prototype clinical CBCT scanner, the dynamic spatial reconstructor was adapted for angiography in 1982 developed by the Mayo Clinic Biodynamic Research Laboratory. [15]

Exploration of CBCT imaging technologies for use in radiation therapy guidance began in 1992.

The technology transfer of CBCT to dentistry first occurred in 1995.

This is followed by integration of the first CBCT imaging system into the gantry of a linear accelerator in 1999. [16]

The first CBCT system become commercially available for dentomaxillofacial imaging in 1999 in Europe (New Tom QR DVT 9000; Quantitative Radiology, Verona, Italy) and in 2001 in US CBCT was initially introduced for its indispensible role in dental implantology.

Currently the utility encompasses fields of implantology, oral surgery, orthodontics, endodontics, sleep apnea, temporomandibular joint disorders and periodontics and is expanding its horizon in the field of ear, nose and throat (ENT) medicine.

The recent review by Dorfler et al of the neurointerventional applications of CBCT is of particular interest to the field of neuroradiology.

Fundamental principles of CBCT

All CT scanners consist of an x ray source and detector mounted on a rotating gantry. During rotation of gantry, the x rays attenuated by the patient. These recordings constitute “raw data” that is reconstructed by a computer algorithm to generate cross-sectional images whose component picture element (pixel) values correspond to linear attenuation coefficients.

Differences between CT and CBCT

CT can be divided into two categories on the basis of acquisition x ray beam geometry, namely fan beam and cone beam. Medical CT utilizes a narrowly collimated fan shaped x ray beam and a linear array of detectors (single row or a series 4,8,12,32 and latest 64) and the patient has to be advanced continuously through the gantry while the x-ray beam and the detectors rotates around the patient. CBCT by the virtue of terminology is a form of CT. Cone Beam scanners uses a 2D digital array providing an area detector rather than a linear detector as CT does. This is combined with a 3D x-ray beam with circular collimation so that resultant beam is cone shaped. Since the exposure incorporates the entire region of interest, only one rotational scan of the gantry is necessary to acquire enough data for image reconstruction. Cone beam geometry has inherent quickness in volumetric data acquisition and also produces an entire volumetric data set from which voxels are extracted. Voxel dimensions are dependent on the pixel size on the area detector. Hence the CBCT units provide voxel resolutions that are isotropic (equal in all three dimensions).

Pixel vs Voxel information

Pixel or picture element is a small rectangle, anywhere between 20 to 60 microns. It represents the smallest single component of an image on a two dimensional grid. The intensity, hue and value of a pixel can vary, thus displaying multiple combinations of data elements, projected using an electronic display grid or printed on a photographic medium, will form accuarate rendering or image. The image can be viewed in color or as black and white image using a gray scale. The attenuation of an X ray signal by an object or tissue will determine the value and the intensity of the individual pixels.

Voxel or volume pixel adds the third dimension to the digital image by adding Z axis (depth) to the X axis(width) and the Y axis(height). Stacks of these volumetric boxes of data allow 360 degrees of virtual manipulation of imaged objects. In short voxel is the smallest element in 3D environment. The size of voxel determines the resolution of the image.

IMAGE ACQUISITION

CBCT unit may have one of two image detectors namely flat panel imager (solid state sensor coupled to a x ray scintillator) or an image intensifier-charge coupled device combination. CBCT uses a scanning arc anywhere between 180^0 and 360^0 for data acquisition. The large volume of raw data necessitates a workstation platform (processing computer) and appropriate software (reconstruction algorithms). Unlike conventional radiographs the images are without magnification and parallax distortion.

The four basic constituents of CBCT image production are

1. Acquisition configuration
2. Image detection
3. Image reconstruction
4. Image display

Acquisition configuration

Patient positioning

Cone beam machines scan patients in three positions

1. Sitting
2. Standing
3. Supine

With all systems it is important to immobilize the patient's head because any movement degrades the final image.

X ray generation

During the scan rotation each projection image is made by consecutive, single image capture of attenuated x ray beams by the detector. The x-ray beam is pulsed to coincide with detector sampling which means that actual exposure time is markedly less than scanning time. This reduces patient radiation dose considerably.

Field of View: FOV or scan volume could be defined as area of interest to be covered during the scanning procedure. The dimensions of FOV depends on detector size and shape, beam projection geometry, collimation of the beam. The shape of scan volume can be cylindrical or spherical. An optimal FOV can be selected for each patient, depending upon disease and the region selected to be imaged, by limiting field size.

CBCT systems can be classified on the basis of available FOV as

- Localized region: approximately 5 cm or less (eg, dentoalveolar, temporomandibular joint)
- Single arch: 5 cm to 7 cm (eg, maxilla or mandible)
- Interarch: 7 cm to 10 cm (eg, mandible and superiorly to include the inferior concha)
- Maxillofacial: 10 cm to 15 cm (eg, mandible and extending to Nasion)
- Craniofacial: greater than 15 cm (eg, from the lower border of the mandible to the vertex of the head). [17]

Stitching **:** Small or medium FOV can be stitched with software programs to enable visualization of larger areas.

Scan factors: when scan progresses, single exposures are made at definite degree intervals, generating individual 2D projection images known as **basis, frame or raw images** which are similar to lateral, oblique, PA, AP cephalometric radiographic images each slightly offset from one another. The complete set of images is known as **projection data.** The number of images comprising the projection data throughout the scan is determined by the **frame rate** (number of images acquired per second), the completeness of the trajectory arc, and the speed of the rotation. Higher frame rates provide images with fewer artifacts and better image quality. However, the greater number of projections proportionately increases the amount of radiation a patient receives.

Image Reconstruction: The basis projection frames acquired are processed to create the volumetric data set known as primary reconstruction which is a computationally complex process. Reconstruction times vary depending on acquisition parameters (voxel size, size of imaging field, number of projections) and hardware (processing speed, data throughput from acquisition to workstation computer) and software (reconstruction algorithms) used. Reconstruction process consists of two stages: **acquisition stage** (where images are calibrated and corrected for inherent pixel imperfections and uneven exposure performed at acquisition computer) and **reconstruction stage** where corrected images converted into composite image called sonogram and the process is called radon transformation. This sonogram is then reconstructed with a filtered back projection algorithm for CBCT acquired volumetric data called the Feldkamp algorithm. Once all slices have been reconstructed, they are combined into a single volume for visualization. [18]

DISPLAY

The volumetric data set is a compilation of all available voxels and for most CBCT devices, is presented to the clinician on screen as secondary reconstructed images in three orthogonal planes (axial, sagittal, and coronal), usually at a thickness defaulted to the native resolution. Optimum visualization of orthogonal reconstructed images is dependent on the adjustment of window level and window width to favor bone and the application of specific filters.

MULTIPLANAR REFORMATION

Because of the isotropic nature of the volumetric dataset, data sets can be sectioned non orthogonally. Most software provides for various non axial two-dimensional images, referred to as multiplanar reformation (MPR). Such MPR modes include oblique, curved planar reformation and serial transplanar reformation. Because of the large number of component orthogonal images in each plane and the difficulty in relating adjacent structures, two methods have been developed to visualize adjacent voxels. Any multiplanar image can be "thickened" by increasing the number of adjacent voxels included in the display. This creates an image slab that represents a specific volume of the patient, referred to as a ray sum. Full-thickness perpendicular ray sum images can be used to obtain images similar to routine X ray radiograph. Unlike conventional radiographs, these ray sum images are without magnification and parallax distortion. However, this technique uses the entire volumetric data set and interpretation suffers from the problems of " anatomic noise " — the superimposition of multiple structures.

Three-Dimensional Volume Rendering

Volume rendering refers to techniques that allow the visualization of 3D data by integration of large volumes of adjacent voxels and selective display. Two specific techniques are available.

Indirect volume rendering is a complex process requiring selection of the intensity or density of the gray scale level of the voxels to be displayed within an entire data set called segmentation. This requires specific software. It provides a volumetric surface reconstruction with depth.

Direct volume rendering is a much simpler process. The most common technique is maximum intensity projection (MIP) technology. MIP visualizations are achieved by evaluating each voxel value along an imaginary projection ray from the observer 's eyes within a particular volume of interest and then representing only the highest value as the display value. Voxel intensities that are below an arbitrary threshold are eliminated. Other modes of display are Min IP (minimum intensity projection), SSR (shaded surface rendering),VR (volume rendering).

ADVANTAGES AND DISADVANTAGES of CBCT

CBCT is well suited for imaging the craniofacial area. The risk versus benefit ratio must be borne in mind prior to prescribing a CBCT scan.

ADVANTAGES

X-ray beam limitation and dose reduction

Reducing the size of the irradiated area by collimation of the primary x-ray beam to the area of interest minimizes the radiation dose. Most CBCT units can be adjusted to scan small regions for specific diagnostic tasks. Others are capable of scanning the entire craniofacial complex when necessary. The effective patient exposure dose in a CBCT scan is anywhere between 45 μSv and 650 μSv.

Image accuracy: Small voxel size permit sub millimeter resolution (as low as .125mm). This implies that very subtle changes in the maxilla and mandible can be discerned by this technique.

Rapid scan time*:* a single pass of the source permits a reduction in total scan time (< 30 sec) .

Display modes unique to maxillofacial imaging*:* reconstruction of CBCT data is performed natively by a personal computer. In addition, software can be made available to the user, not just the radiologist, either via direct purchase or innovative "per use" licence from various vendors (e.g., Imaging Sciences International). This provides the clinician with the opportunity to use chair-side image display, real-time analysis and MPR modes that are task specific. Because the CBCT volumetric data set is isotropic, the entire volume can be reoriented so that the patient's anatomic features are realigned. In addition, cursor-driven measurement algorithms allow the clinician to do real-time dimensional assessment.

Reduced image artifact*:* With manufacturers' artifact suppression algorithms and increasing number of projections, CBCT images can result in a low level of metal artifact, particularly in secondary reconstructions designed for viewing the teeth and jaws.

Size and cost of equipment: physical footprint being much smaller and favorable costing of equipment are the advantages of CBCT which make it available for dental clinics. [19]

DISADVANTAGES

Image Noise: the large volume of tissue being irradiated results in poly directional Comptom scattering, that is image noise is more for CBCT despite the high resolution.

Poor soft tissue visualization: this is due to inherent draw backs in flat panel detector technology and scatter which produces detrimental signals reducing the ability to delineate soft tissue.

Image artifacts : As the x-ray beam which is polychromatic in nature passes through the object to be imaged, lower energy x-ray photons are attenuated by the object first. This results in an increase in the mean energy of the residual x-ray beam which is said to become "harder". The phenomenon of beam hardening results in three types of artifacts: streak, dark bands and cupping artifacts. Streaks and dark bands occur when the x-ray beam is hardened to different degrees as it passes through different parts of a heterogeneous object at various tube positions. This type of artifact is common in bony regions of patients and when contrast material is used. Cupping artifacts result when the x-ray beam passing through the thicker middle portion of an object becomes harder than the beam passing through the thinner edges of the object. The harder beam is attenuated less and the resultant image appears darker in the center. Beam hardening software is used by manufacturers to correct for th these artifacts and sometimes overcorrection is attempted to minimize blurring at the bone-soft tissue interface of an image. In some instances, capping artifacts result and the reverse becomes true with the edges of the image appearing darker than the center. Patient movement causes artifacts in the form of blurriness of the resultant image. To overcome this problem, manufacturers provide head rests and straps to stabilize the patients' head during a scan. Ring artifacts are due to detector imperfections or poor calibration. Partial volume averaging artifact is commonly seen in CBCT images. This artifact occurs when dense parts of a heterogeneous object protrude partway into the FOV causing shading artifacts to appear. Under sampling is another common CBCT artifact that appears as a noisy reconstructed image with streaks when the number of basis images is reduced. The divergent nature of the CBCT x-ray beam may also result in artifacts like distortion and peripheral noise.

REPORTING

Cone-beam imaging comprises not only the technical component of patient exposure but a responsibility for interpreting the resultant volumetric data set. Documentation of an imaging examination is an important part of a patient's medical record. The mechanics of image reporting include the development of a series of images formatted to display the condition/region appropriately (image report) and a cognitive interpretation of the significance of the imaging findings.

ARCHIVING, EXPORT, AND DISTRIBUTION

The process of CBCT imaging produces two data products, the volumetric image data from the scan and the image report generated by the operator. Both sets of data must be archived and distributed. Scan data backup is usually performed in its native or proprietary image format. Export of image data is usually in the DICOM (Digital Imaging and Communications in Medicine) file format standard for use in specialized software. [8]

CLINICAL APPLICATION IN DENTISTRY

Although CBCT indisputably plays a major role in the decision making process of a treatment plan generally **Clinical application of CBCT can be summarized as**

Maxillofacial Pathology and Surgery	1. Jaw pathology. 2. Planning orthognathic and facial orthomorphic surgeries 3. Evaluation of impacted teeth, supernumerary and their relation to vital structures. 4. Pre and post-surgical evaluation of craniofacial fractures. 5. Assessment of bone graft. 6. Assessment of paranasal sinuses. 7. Alteration of cortical and trabecular pattern. 8. Pretreatment evaluation of obstructive sleep apnea. [20, 21]
Implant planning and anatomical assessment	1. Precision implant planning . 2. Assessment of ridge morphology and quality of bone. [22] 3. To assess position of vital anatomical structures. 4. Preparation of templates/surgical stents. 5. Post-surgical review evaluation. [23]
Periodontics	1. To assess bone morphology(wall defects furcation involvement etc) 2. Graft and graft volume. [24]
Orthodontics	1. Cephalometric analysis. [25] 2. Airway function and analysis. 3. To assess proximity of impacted teeth to vital structure.

	4. Guides safe insertion of mini screw implants 5. To assess bone density. 6. Development anomalies and asymmetries of the face and skull can be assessed. [26]
TMJ analysis	1. To delineate the true position of condyle in the fossa and to visualize the degree of translation of the condyle in the fossa 2. To measure roof of glenoid fossa 3. To do image guided puncture technique 4. To identify condylar cortical erosion, cysts and fragments of bone calcifications.
Endodontics	1. Assessment of root canal morphology 2. To identify periapical pathoses, and to assess its relationship to surrounding structures. 3. Aids in periradicular surgical treatment planning
Forensic dentistry	1. Age estimation 2. Osseous morphology assessment 3. Non-invasive forensic evaluation of anatomy
Miscellaneous applications	1. Study of paranasal sinuses, skull bases, temporal skull, pituitary fossa volume. **2.** Volumetric assessment of developmental defects including cleft of palate**.** [27, 28]

Lindh C, Petersson A did a study 1n 1989 comparing panoramic radiography with Conventional tomography as techniques for visualizing the mandibular canal. Tomography gave a significantly clearer image of the canal at and 1 cm posterior to the mental foramen, while no differences were found between the methods 2 cm posterior to the mental foramen. The study concluded that tomography could be of great value in locating the mandibular canal before implant surgery in edentulous mandibular posterior segments. [29]

Denio D, Torabinejad M, Bakland LK studied the Anatomical relationship of the mandibular canal to its surrounding structures in mature mandibles. Twenty-two mature dried mandibles were sectioned through the root apices of the first and second premolars and molars. Second premolars and second molars had the closest distances to the canal with a mean of 4.7 mm and 3.7 mm, respectively. With a mean of 6.9 mm, the apices of the mesial roots of the first molars were farthest from the canal. The canal pathway in mature mandibles followed in S-shaped curve in 31% of the cases. In 41% of the cases it was located lingual (19%), buccal (17%), or directly inferior (5%) to the apices of the posterior teeth. In 28% of the cases the canal could not be identified clearly in the second premolar and first molar regions. [30]

Gowgiel JM in 1992 did a study, observing changes in the position and course of the mandibular canal on twenty-nine human cadaver mandibles. In this study the neurovascular bundle was located in contact with, or very close to, the lingual cortical plate until it reached the mental foramen. Anterior to the mental foramen, the neurovascular bundle was not a distinct entity and was located close to the labial cortical plate. In the body of the mandible, the neurovascular bundle was located about one centimeter above the mandibular inferior border. The distance from the lateral border of the neurovascular bundle to the external surface of the buccal plate was usually half a centimeter in the molar and premolar region. [31]

A study done by Htar Htar Aung, Nazih Shaaban Mustafa in 2012 on 28 patients assessing the differences of the level of mandibular canal and mental foramen by using orthopantomographs (OPG) and cone beam computed tomography (CT). They concluded that the measurements with CT is higher and more accurate in comparing with the findings of OPG. [32]

Wadu SC, Penhall B, Townsend GC did a study to compare the radiographic appearance of the neurovascular bundle and its surrounding bone with the actual situation revealed on dissection; to reveal the morphology of the neurovascular bundle in dentate and edentulous subjects; and to note any changes occurring following the removal of the teeth and the consequent resorption of alveolar bone. Twenty-nine human mandibles were examined; 20 were dry skeletal specimens that were examined radiographically and the remaining nine were radiographed then dissected after decalcification and the branches of the inferior alveolar nerve were identified, sketched, and photographed. Different patterns of identifying characteristics of the mandibular canal were noted on the radiographs, ranging from alternating bands of radiopacity and radiolucency to continuous radiopaque lines. Dissections indicated that the radiographic appearance related to the number, distribution, and pattern of trabeculae around the canal. The dissections revealed that in all cases, the main nerve divided into its incisive and mental branches in the molar area well before reaching the mental foramen. A branch to the molar teeth, and in two instances to the second premolar as well, was given off from the main trunk before it divided into incisive and mental branches. In the dentate specimens, the neurovascular bundle formed two distinct curvatures, one between the mandibular and mental foraminae and the other between the mental foramen and the incisor teeth apices. In the edentulous specimens, the neurovascular bundle was reduced in size and although some small nerve branches, notably to the molar areas, were distinguishable, the blood vessels seemed to have atrophied beyond macroscopic identification. This study confirmed the inaccuracy of descriptions repeated in many anatomical textbooks suggesting that the inferior alveolar branch of the trigeminal nerve divides at the mental foramen into its incisive and mental branches and that during their path through the body of the mandible they give off fibers to the individual teeth. It further confirmed that the neurovascular bundle reduces in size quite markedly after removal of teeth and that the vascular component cannot be clearly identified. [33]

Neiva et al. did a study on morphometric analysis of implant-related anatomy in Caucasian skulls results suggested that the mental foramen was 27.6 mm (range: 22 to 31 mm) from the midline and 12mm (range: 9 to 15 mm) superior to the most apical portion of the lower cortex of the mandible. [34]

Kobayashi K, Shimoda S, Nakagawa Y, Yamamoto A in 2004 did a study to evaluate the accuracy of measurement of distance on the images produced by limited cone-beam computerized tomography (CT). LCBCT was shown to be a useful tool for preoperative evaluation in dental surgery because the relatively small field size of its images limits the patient's exposure to radiation. [35]

Agthong et al. in his study on Anatomical variations of the supraorbital, infraorbital, and mental foramina related to gender and side found that the mental foramen was 28 mm lateral to the midline of the mandible and 14 to 15 mm superior to the inferior border of the mandible. [36]

Paes Ada SF, Moreira CR, Sales MAO, Cavalcanti MGP in 2007 did a study in 26 printed CT films (7 SSCT and 19 MDCT) to evaluate the accuracy of relative measurements from the roof of the mandibular canal to the alveolar crest in multislice (multidetector) computed tomography (MDCT) and single-slice computed tomography (SSCT). The sample consisted of Multislice CT was demonstrated a more accurate method and demonstrated high reproducibility in the analysis of important anatomical landmarks for planning of mandibular dental implants, namely the mandibular canal pathway and alveolar crest height. [37]

Tantanapornkul W, Okouchi K, Fujiwara Y, Yamashiro M, Maruoka Y, Ohbayashi N, et al in 2007 did a study to evaluate the diagnostic accuracy of cone-beam CT compared with panoramic images in predicting neurovascular bundle exposure during extraction of impacted mandibular third molars. Cone-beam CT and panoramic images of 142 impacted mandibular third molars were prospectively evaluated to assess tooth relationship to the mandibular canal. The sensitivity and specificity of the 2 modalities in predicting neurovascular bundle exposure at extraction were calculated and compared. This study concluded that in predicting the exposure, the sensitivity and specificity were 93% and 77% for cone-beam CT, and 70% and 63% for panoramic images, respectively. Cone-beam CT was significantly superior to panoramic images in predicting neurovascular bundle exposure during extraction of impacted mandibular third molar teeth. [38]

A study done by Weeraya et al in 2007 comparing 142 impacted third molars by cone-beam computed tomography and conventional panoramic radiography in assessing the topographic relationship between the mandibular canal and impacted third molars**.** Cone-beam CT was significantly superior to panoramic images in predicting neurovascular bundle exposure during extraction of impacted mandibular third molar teeth.[39]

A study was conducted by Levine et al. to measure the position of the IANC at the level of first molar and to identify variables that may be associated with the position of the IANC. Direct buccal linear measurement was made from the buccal cortical margin of the IANC to the lateral (buccal) cortical margin of the mandible and direct vertical linear measurement was also made from the alveolar crest to the superior aspect of the IANC. They concluded that the IANC was 4.9 mm and 17.4 mm from the buccal and superior cortical surfaces of the mandible, respectively. The bucco-lingual IANC position was associated with age and race. Older patients and white patients, on average, have less distance between the buccal aspect of the canal and the buccal mandibular border. [40]

Patel S et al. have studied the potential applications of CBCT in managing patients with endodontic pathology and concluded that CBCT is helpful for clear visualization of the relationships of the root apices to various neighboring anatomic structures such as the mandibular canals and the maxillary sinuses. [41]

Loubele M, Jacobs R, Maes F, Denis K, White S, Coudyzer W, et al in 2008 did a study to evaluate image quality by examining segmentation accuracy and assess radiation dose for cone beam CT (CBCT) scanners. The results for the DPI(100,c) were 107 mGy mm for Accuitomo 3D, 1569 mGy mm for MercuRay, 446 mGy mm for NewTom 3G, 249 mGy mm for i-CAT and 1090 mGy mm for Sensation 16. The segmentations in the contrast phantom were submillimeter accurate in all scanners. The segmentation accuracy of the mandible was 2.9 mm for Accuitomo 3D, 4.2 mm for MercuRay, 3.4 mm for NewTom 3G, 1.0 mm for i-CAT and 1.2 mm for Sensation 16. The correlation between measurements in the contrast and skull phantom was below 0.37 mm. This study concluded that the best radiation dose vs image quality was found for the i-CAT. [42]

Angelopoulos C, Thomas SL, Hechler S, Parissis N, Hlavacek M in 2008 did a study on Comparison between digital panoramic radiography and cone-beam computed tomography for the identification of the mandibular canal as part of presurgical dental implant assessment. According to their study the CBCT reformatted panoramic images outperformed the digital panoramic images in identification of the mandibular canal. [13]

Naitoh M, Katsumata A, Kubota Y, Hayashi M, Ariji E. did a study in 23 patients to clarify the relationship between the depiction of the mandibular canal in digital panoramic images and cancellous bone density assessed using multislice computed tomographic images. In this study the mean pixel value in the site of the mandibular canal visible in the superior and inferior walls was significantly larger in comparison with that invisible in the superior and inferior walls. The depiction of the mandibular canal in digital panoramic images was related to bone density in the alveolar region. [43]

Kamburoğlu K, Kiliç C, Ozen T, Yüksel SP in 2008 did a study on measurements of mandibular canal region obtained by cone-beam computed tomography. The study concluded that accuracy of cone-beam CT measurements of various distances surrounding the mandibular canal was comparable to that of digital caliper measurements. [44]

Lofthag-Hansen S, Gröndahl K, Ekestubbe A in 2009 did a retrospective study to evaluate the visibility of the mandibular canal and the marginal bone crest and the agreement between observers in images from one CBCT technique. With their CBCT modality (3D Accuitomo), the visibility of the mandibular canal and the marginal crest, as well as the observer agreement of the location of these structures, was high. And concluded that 3D Accuitomo can be recommended for implant planning in the posterior mandible. [45]

CHEN et al in 2009 did a study to evaluate the diagnostic accuracy of the panoramic radiograph in judging the relationship between the impacted mandibular third molar (IMTM) and the inferior alveolar canal (IAC) by cone-beam computed tomography (CBCT) and give guidelines for using radiological examinations before IMTM extraction. This study concluded that Panoramic radiography can be used to screen out high-risk cases of inferior alveolar nerve injury before the IMTM extraction. Those IMTMs superimposing the canal partially or touching the canal in line on panoramic radiographs should be examined by CBCT further. Two features on panoramic radiographs, including interruption of the alveolar lamina dura and periodontal space, and interruption of the radiopaque border of the canal, were more valuable than other signs to predict impingement and interruption of the IAC wall. [46]

In a study by Kim et al in 2009 on Location of the mandibular canal and the topography of its neurovascular structures, classified the buccolingual location of the IAN into 3 types. Most cases (70%) were type 1, in which the IAN canal follows the lingual cortical plate of the mandibular ramus and body. In type 2 (15%), the IAN canal is located in the middle of the mandibular ramus posterior to the second molar. It then runs lingually to follow the lingual plate. In type 3 (15%), the IAN canal is located near the middle of the ramus and body. [47]

Liang X, Jacobs R, Hassan B, Li L, Pauwels R, Corpas L, et al in 2010 compared the image quality and visibility of anatomical structures in the mandible between five Cone Beam Computed Tomography (CBCT) scanners and one Multi - Slice CT (MSCT) system. CBCT image quality is comparable or even superior to MSCT even though some variability exists among the different CBCT systems in depicting delicate structures. Considering the low radiation dose and high resolution imaging, CBCT could be beneficial for dentomaxillofacial radiology.[48]

Bothaina M. A'Akil, SaadW. Al Bayatti did a study to evaluate the distance between the mandibular canal and the lower third molars, distance between the mandibular canal and the lower cortex of the mandible in 100 radiographs. In this study, it was found that 16 % of the cases touching the upper border of the mandibular canal in right side and 31% in left side which indicates the presence of a deviation of the inferior dental canal. [49]

A study done by Kyung-Hwan Kwon, Kyu-Bong Sim, Jae-Min Lee in 2012 evaluating the course of the inferior alveolar canal in the mandibular ramus using cone beam computed tomography. Marking osteotomy lines in the retromolar area in procedures involving bone harvesting is discouraged due to the risk of damage to IAC structures. Measurements from this study indicated that the area from the R point in the ramus of the mandible to 10 mm anterior can be safely harvested for bone grafting purposes. [50]

A Study done by Balaji S M, Krishnaswamy N R, Manoj Kumar S, Rooban T on 20 south Indian patients measuring the inferior alveolar canal position, they concluded that on average, the lingual cortical thickness was 1.68 mm at 1st molar and 1.44 at 2nd molar level. Gender and side influenced the outcome with statistical significance. [51]

A study done by Seema Patil et al assessing the incidence, course, and characteristics of retromolar canals. The cone-beam computed tomography images of 171 subjects were evaluated for the presence, course, and pattern of occurrence of retromolar canals. From this study three types of retromolar canals namely A, B, & C were detected in 129 subjects.[52]

A study done by Nair et al in 2013 in 44 patients to evaluate the course of the inferior alveolar canal (IAC) including its frequently seen variations in relation to root apices and the cortices of the mandible at fixed pre-determined anatomic reference points using cone beam computed tomography (CBCT). IACs were noted to course superiorly toward the root apices from the second molar to the first premolar and closer to the buccal cortical plate anteriorly. The canal was closest to the LCP at the level of the second molar. In 32.95% of the cases, the canal was seen at the level of the canine. Their study concluded that caution needs to be exercised during endodontic surgical procedures in the mandible even at the level of the canine. CBCT seems to provide an optimal, low-dose, 3D imaging modality to help address the complexities in canal configuration.[53]

Sekerci et al confirmed the presence of retromolar canal using CBCT in two female patients and the authors believe that their study will aid to the confirmation of the “RMC;” thus, permitting the planning of surgery with a lower risk of surgical damage. [54]

A study done by Xu et al to explore the anatomic relationship between impacted third mandibular molar and the mandibular canal as the risk factor of inferior alveolar nerve injury. The study concluded that the risk of damage to the inferior alveolar nerve is increased if third molars intersect with the mandibular canal, particularly on its buccal side. [55]

A study was done by Iyengar AR, Patil S, Nagesh KS, Mehkri S, Manchanda A on Detection of anterior loop and other patterns of entry of mental nerve into the mental foramen in panoramic radiographs they concluded that Panoramic radiography may not be a very reliable imaging modality for identifying the presence of anterior loop.[56]

A study done Shujaat et al in 2014 assessing the relationship between inferior dental nerve canal and mandibular impacted third molar using CBCT. This study concluded that inferior dental canal was most frequently approximate to the lingual plate and inferior to the 3rd molar. [57]

Osama Alabed Mela , Mohamed Abdel- Monem Tawfik , Noha Ahmed Mansour in 2014 did a study is to evaluate the role of cone-beam computed tomography (CBCT) in the assessment of the relation between the mandibular canal and impacted third molars in 43 patients. Cone-beam computed tomography examination showed that Interruption of white line were significantly associated with contact status (residuals > ±1.69). With the absence of corticalization between the impacted mandibular third molar and the mandibular canal on panoramic radiographs. All other panoramic radiographic signs showed no association with contact status (residuals < ±1.69). According to this study panoramic radiography is an effective method for pre-operative assessment of mandibular third molars. Interruption of white line observed on panoramic radiographs, as isolated finding or in association with root darkening, are effective in determining the risk relationship between the tooth roots and the mandibular canal, requiring 3D evaluation of the case. [58]

Vizzotto, et al. in 2014 assessed the Buccal-lingual localization of the mandibular canal in relationship with the third molar using the lateral oblique technique. The results of this study showed that LOR (lateral oblique radiography) (0° e –30°) could be used to determine the bucco-lingual location of the mandibular canal with respect to the third molar. Mandibular canal position using lateral oblique technique. [59]

SOURCE OF THE DATA:

This study was carried out at the Maxillofacial Diagnostics, Ernakulam and the Department of Oral Medicine and Radiology. Sree Mookambika Institute of Dental Sciences, Kulasekharam, KanyaKumari district.

METHODS OF SELECTION OF DATA:

I. SAMPLE SIZE

Total sample size of the study: 90

Group 1- Images patients of age <20 years (n=30)

Group 2- Images of patients of age 20-40 years (n=30)

Group 3- Images of patients of age 41-65 years (n=30)

II. SELECTION OF CASES

a. Inclusion criteria:

Group 1

Images of patients (both male & female) of age <20 years.

Presence of at least two posterior teeth (excluding third molar) in one quadrant

Group 2

Images of patients (both male & female) of age 20-40 years.

Presence of at least two posterior teeth (excluding third molar) in one quadrant

Group 3

Images of patients (both male & female) of age 41-65 years.

Presence of at least two posterior teeth (excluding third molar) in one quadrant

Exclusion criteria:

- Presence of cysts and tumors in mandibular posterior regions.
- Any conditions that alter the configuration of inferior alveolar canal and morphology of root.

PROCEDURE:

Previously exposed cone beam computed tomographic images of patients which satisfies our inclusion criteria were obtained from maxillofacial diagnostics imaging centre, Ernakulam. The images were acquired with the Sirona orthophos XG 3D machine (Germany). The tube voltage was generally set at 90 kvp, the tube current at average 5 mA and the exposure time was approximately 20s. The height of the field of view (FOV) was 8 cm and the diameter was also 8 cm. The voxel size was 0.4 mm. Measurements from the IAC to the root apices of the molars, first and second premolars was obtained from cross sectional reformatted images. Other measurements included the distance from the Inferior alveolar canal to the buccal, lingual cortical plates (LCP) from the respective boundaries of the Inferior alveolar canal, parallel to the X-axis on paracoronal slices at the above locations, as well as inferior borders of the mandible, parallel to the Y-axis. The sagittal, coronal and axial images which were reconstructed from the projection data were used for assessing the configuration of inferior alveolar nerve and its relationship to roots of mandibular posterior teeth. All images were reconstructed on sidexis software. All generated DICOM data were saved in a Seagate freeagent Go 500 GB USB 2.0 Portable External Hard Drive.

RADIOGRAPHIC INTERPRETATION:

Images were exported from the external hard drive to the Intel – Microsoft windows XP professional, version 2002, computer at the department of Radiology, Sree Mookambika Institute of Dental Science, kulasekaram and then imported to the sidexis software. In leiu of the region of interest the focus was on the IAC starting from the distal aspect of the second molar to the mental foramen.

MATERIALS REQUIRED:

1. Sirona orthophos XG 3D machine
2. Sidexis software by Sirona
3. Seagate freeagent Go 500 GB USB 2.0 Portable External Hard Drive
4. Intel – Microsoft windows XP professional, version 2002, Computer

FIGURE 1: SIRONA ORTHOPHOX XG 3D CBCT MACHINE

FIGURE 2: PANOROMIC IMAGE WITH NERVE TRACING

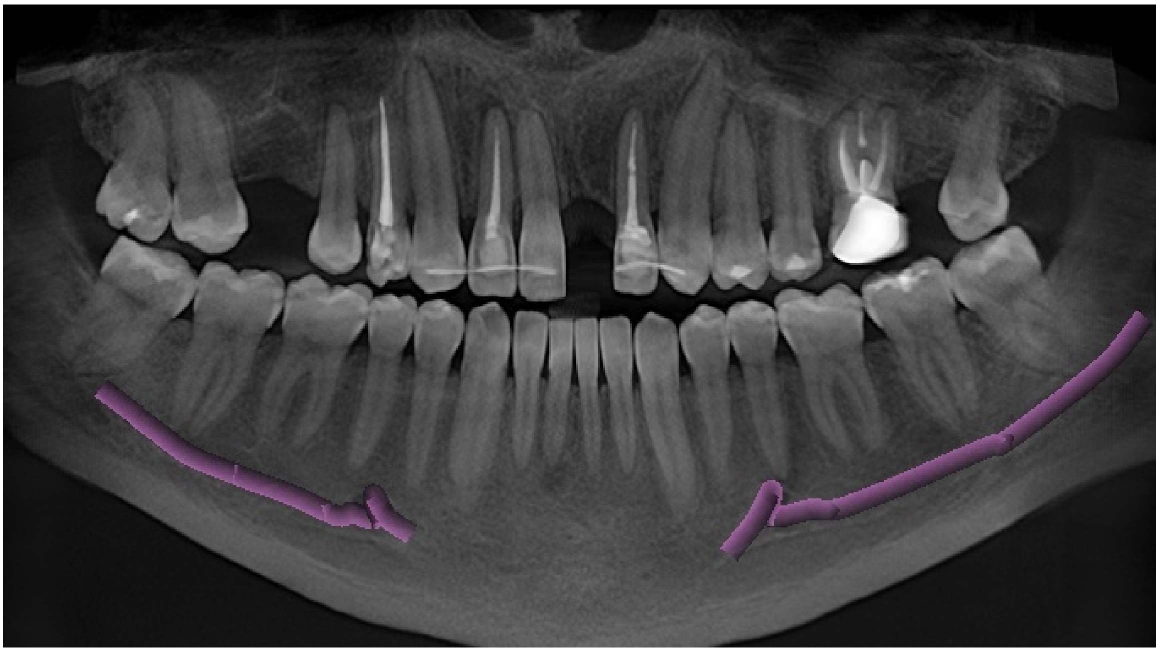


FIGURE 3: IMAGE SHOWING THE POSITION OF IAC IN AXIAL, CROSS SECTIONAL AND TANGENTIAL VIEW

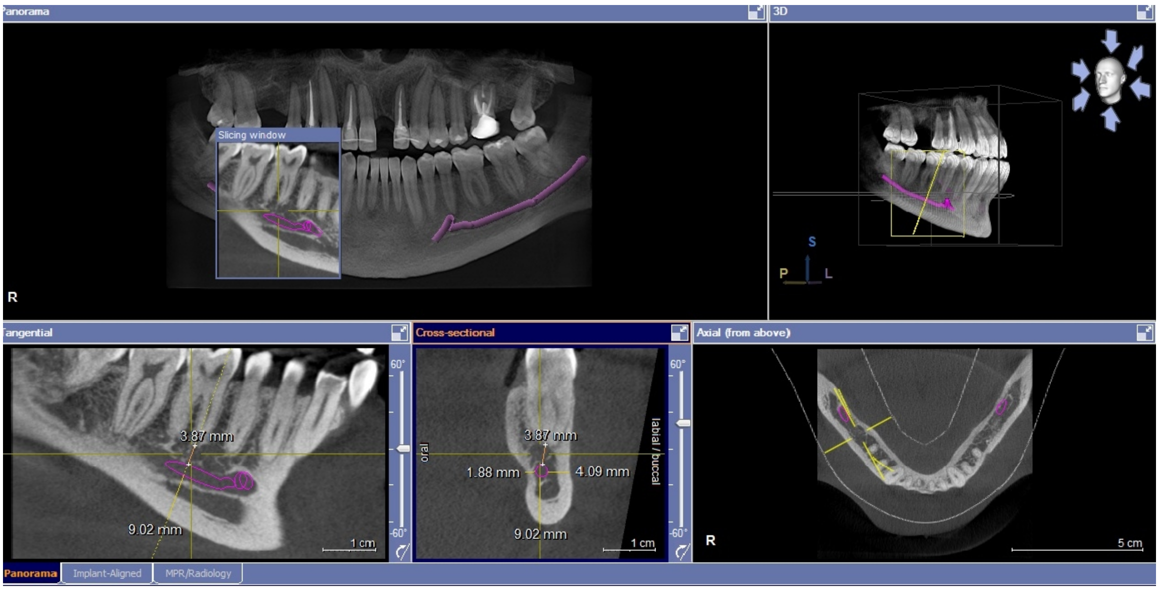


FIGURE 4: CROSS SECTIONAL IMAGE SHOWING THE MEASUREMENTS OF IAC FROM BCP, LCP, INFERIOR BM AND TOOTH APEX IN PREMOLAR REGION

FIGURE 5: CROSS SECTIONAL IMAGE SHOWING THE MEASUREMENTS OF IAC FROM BCP, LCP, INFERIOR BM AND TOOTH APEX IN MOLAR REGION

FIGURE 6: 3D IMAGE SHOWING THE PATH OF IAC

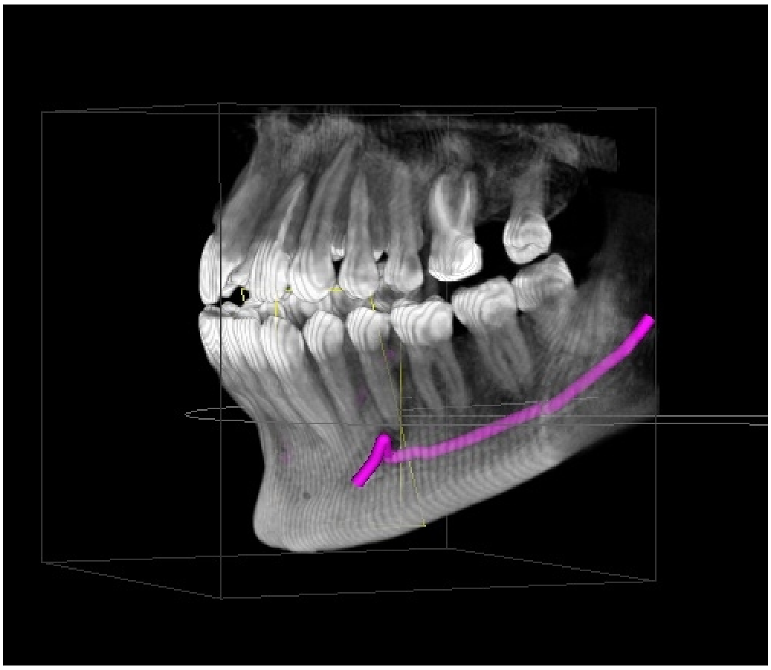


FIGURE 7: 3D IMAGE SHOWING THE COURSE OF IAC (< 20 YEARS)

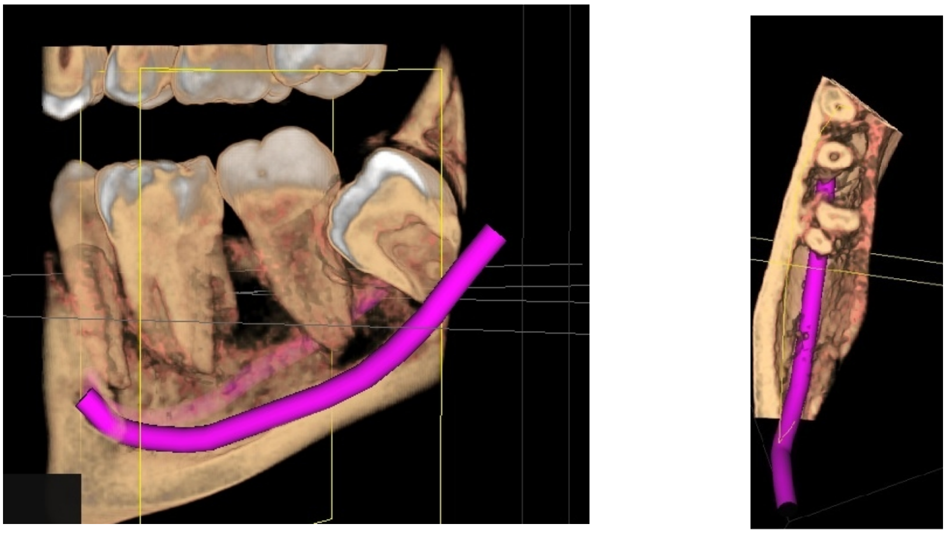


FIGURE 8: 3D IMAGE SHOWING THE COURSE OF IAC (20-40 YEARS)

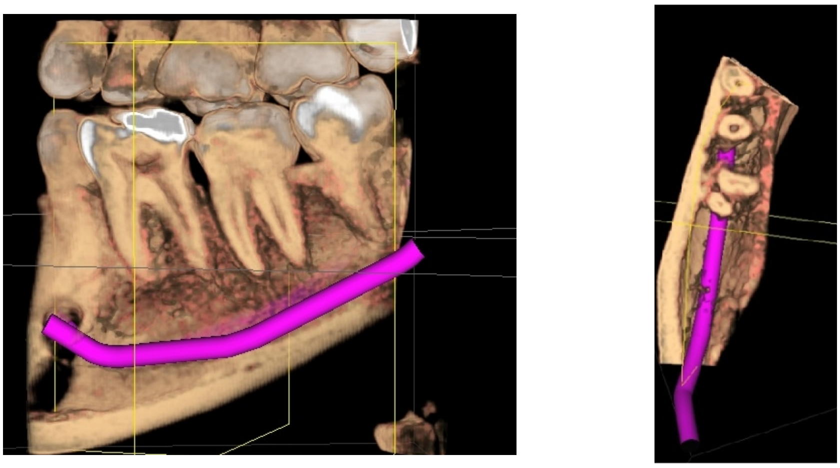
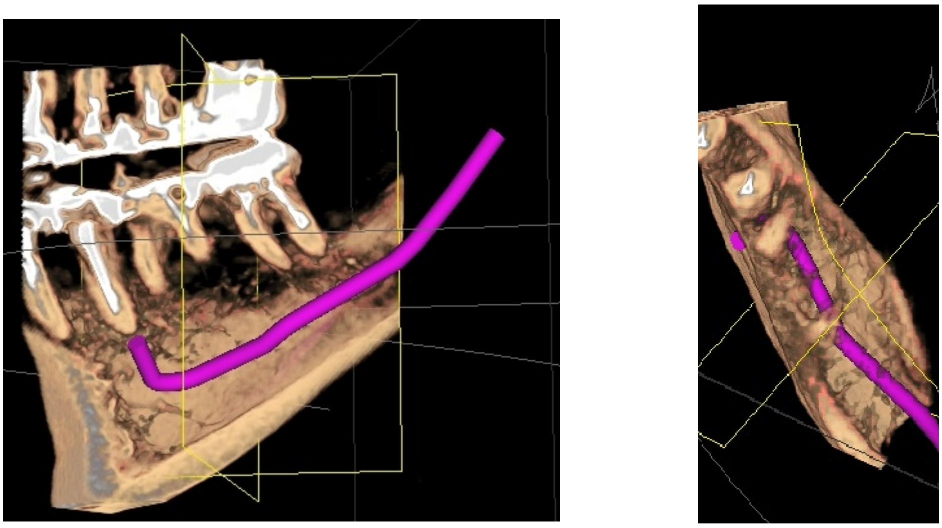


FIGURE 9: 3D IMAGE SHOWING THE COURSE OF IAC (41-65 YEARS)



The present study was undertaken to evaluate the spatial relationship of Inferior alveolar canal in three different age groups using Cone Beam Computed Tomography. The study was carried out on 90 CBCT images, with study groups comprising of images of 30 patients of age <20, 30 patients of age 20-40, and 30 patients of age 41-65 years. The results of this study showed the course of inferior alveolar canal, the mean distance of IAC from buccal cortical plate, lingual cortical plate, inferior border of mandible and root apex for different age groups. Generally the canal was close to BCP in the region of premolars (2.71 mm, first premolars, 2.81 mm, second premolars), the canal was away from BCP in the region of molars (5.89 mm, second molars) (Table 1).

In the region of premolars the distance from IAC to BCP was significantly less in 41 – 65 years group, compared to the younger age groups.

With respect to lingual cortical plate IAC was close to LCP in the region of molars (2.08 mm second molar mesial root, 2.11 mm distal root) (Table 2). With increase in age the distance from LCP to IAC increased in the region of premolars and first molar and decreased in the region of second molars.

The distance from IAC to inferior border of mandible significantly increased with advancing age in our study (Table 3). Also, the distance from IAC to tooth apex increased in 41-65 years group with respect to all teeth when compared to the younger age groups (Table 4).

In 30 teeth, the root apex was in direct contact with inferior alveolar canal, of which 19 were mandibular second molar and majority of them belonged to the <20 years group. Another important finding was the presence of neurovascular bundle at the level of mandibular canine in 28 out of the 90 images studied. In most of the images evaluated (80%) the inferior alveolar canal generally runs close to the lingual cortical plate in the region of second molar and first molar and it moves buccally just anterior to the mesial root of first molars.

To compare mean values between age groups one way ANOVA is applied, followed by Tukey's HSD post-hoc test for pair wise comparison of age groups if found significance in one way ANOVA. To analyse the data SPSS version 22.0 is used.

(If P-Value < 0.05 then statistically significant)

TABLE : 1

a) To compare mean values between age groups. - BCP

One way ANOVA to compare mean values between age groups. - BCP

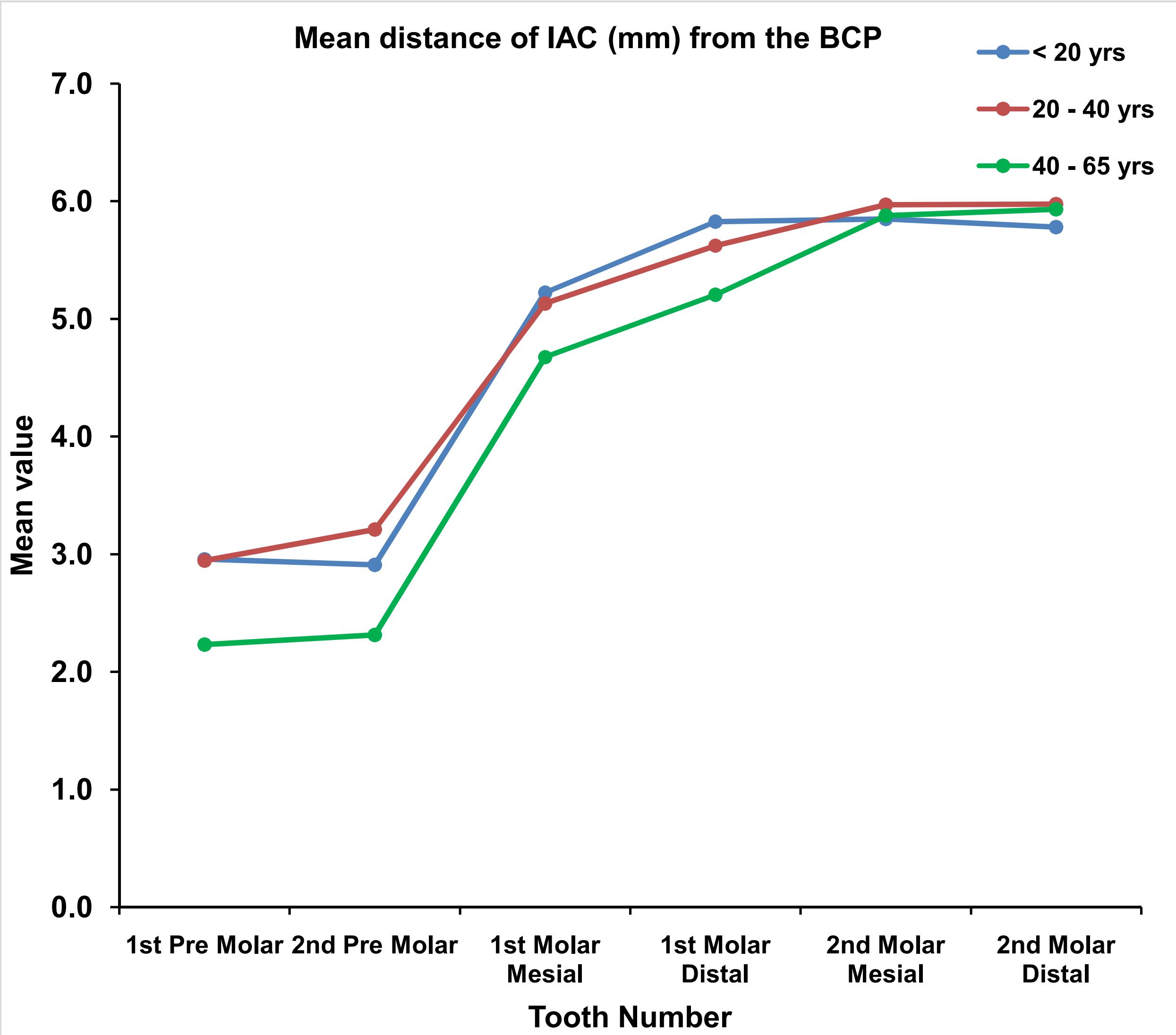
Distances	Group	N	Mean	Std. Dev	F-Value	P-Value
Distance of IAC (mm) from the BCP - 1st Pre Molar	< 20 yrs	60	2.9567	1.12875	10.636	<0.001
	20 - 40 yrs	60	2.9458	.83793		
	40 - 65 yrs	60	2.2318	.97164		
	Total	180	2.7114	1.03838		
Distance of IAC (mm) from the BCP - 2nd Pre Molar	< 20 yrs	60	2.9088	.85446	15.455	<0.001
	20 - 40 yrs	60	3.2098	.89720		
	40 - 65 yrs	60	2.3140	.94094		
	Total	180	2.8109	.96805		
Distance of IAC (mm) from the BCP - 1st Molar Mesial	< 20 yrs	60	5.2245	1.31118	3.960	.021
	20 - 40 yrs	60	5.1302	1.18349		
	40 - 65 yrs	60	4.6758	.88986		
	Total	180	5.0102	1.16061		
Distance of IAC (mm) from the BCP - 1st Molar Distal	< 20 yrs	60	5.8272	1.56634	3.748	.025
	20 - 40 yrs	60	5.6225	1.15657		
	40 - 65 yrs	60	5.2058	1.01199		
	Total	180	5.5518	1.28621		

Distance of IAC (mm) from the BCP - 2nd Molar Mesial	< 20 yrs	60	5.8510	1.51060	.145	.865
	20 - 40 yrs	60	5.9705	1.02508		
	40 - 65 yrs	60	5.8783	1.23690		
	Total	180	5.8999	1.26704		
Distance of IAC (mm) from the BCP - 2nd Molar Distal	< 20 yrs	60	5.7815	1.50522	.386	.680
	20 - 40 yrs	60	5.9760	1.12637		
	40 - 65 yrs	60	5.9327	1.15028		
	Total	180	5.8967	1.26810		

INFERENCE:

Mean value shows the position of canal close to BCP in the region of 1st premolars (2.71 mm), away from buccal cortical plate in the region of second molars (5.89 mm). In the region of premolars distance from IAC to BCP was less in 41-65 yrs group with statistical significance (<0.001)

GRAPH 1: Mean distance of IAC from BCP between age groups



b) ANOVA Table

Distances	Sum of Squares		df	Mean Square	F-Value	P-Value
Distance of IAC (mm) from the BCP - 1st Pre Molar	Between Groups	20.706	2	10.353	10.636	<0.001
	Within Groups	172.297	177	.973		
	Total	193.003	179			
Distance of IAC (mm) from the BCP - 2nd Pre Molar	Between Groups	24.939	2	12.469	15.455	<0.001
	Within Groups	142.806	177	.807		
	Total	167.745	179			
Distance of IAC (mm) from the BCP - 1st Molar Mesial	Between Groups	10.327	2	5.164	3.960	.021
	Within Groups	230.789	177	1.304		
	Total	241.116	179			
Distance of IAC (mm) from the BCP - 1st Molar Distal	Between Groups	12.031	2	6.016	3.748	.025
	Within Groups	284.096	177	1.605		
	Total	296.127	179			
Distance of IAC (mm) from the BCP - 2nd Molar Mesial	Between Groups	.470	2	.235	.145	.865
	Within Groups	286.894	177	1.621		
	Total	287.364	179			
Distance of IAC (mm) from the BCP - 2nd Molar Distal	Between Groups	1.251	2	.626	.386	.680
	Within Groups	286.594	177	1.619		
	Total	287.845	179			

c) Tukey HSD Post Hoc Tests for Multiple Comparisons

Dependent Variable	Group		Mean Difference	P-Value
Distance of IAC (mm) from the BCP - 1st Pre Molar	< 20 yrs	20 - 40 yrs	.01083	.998
		40 - 65 yrs	.72483	<0.001
	20 - 40 yrs	40 - 65 yrs	.71400	<0.001
Distance of IAC (mm) from the BCP - 2nd Pre Molar	< 20 yrs	20 - 40 yrs	-.30100	.161
		40 - 65 yrs	.59483	.001
	20 - 40 yrs	40 - 65 yrs	.89583	<0.001
Distance of IAC (mm) from the BCP - 1st Molar Mesial	< 20 yrs	20 - 40 yrs	.09433	.893
		40 - 65 yrs	.54867	.025
	20 - 40 yrs	40 - 65 yrs	.45433	.078
Distance of IAC (mm) from the BCP - 1st Molar Distal	< 20 yrs	20 - 40 yrs	.20467	.651
		40 - 65 yrs	.62133	.021
	20 - 40 yrs	40 - 65 yrs	.41667	.172

TABLE 2:

a) To compare mean values between age groups. - LCP

One way ANOVA to compare mean values between age groups. - LCP

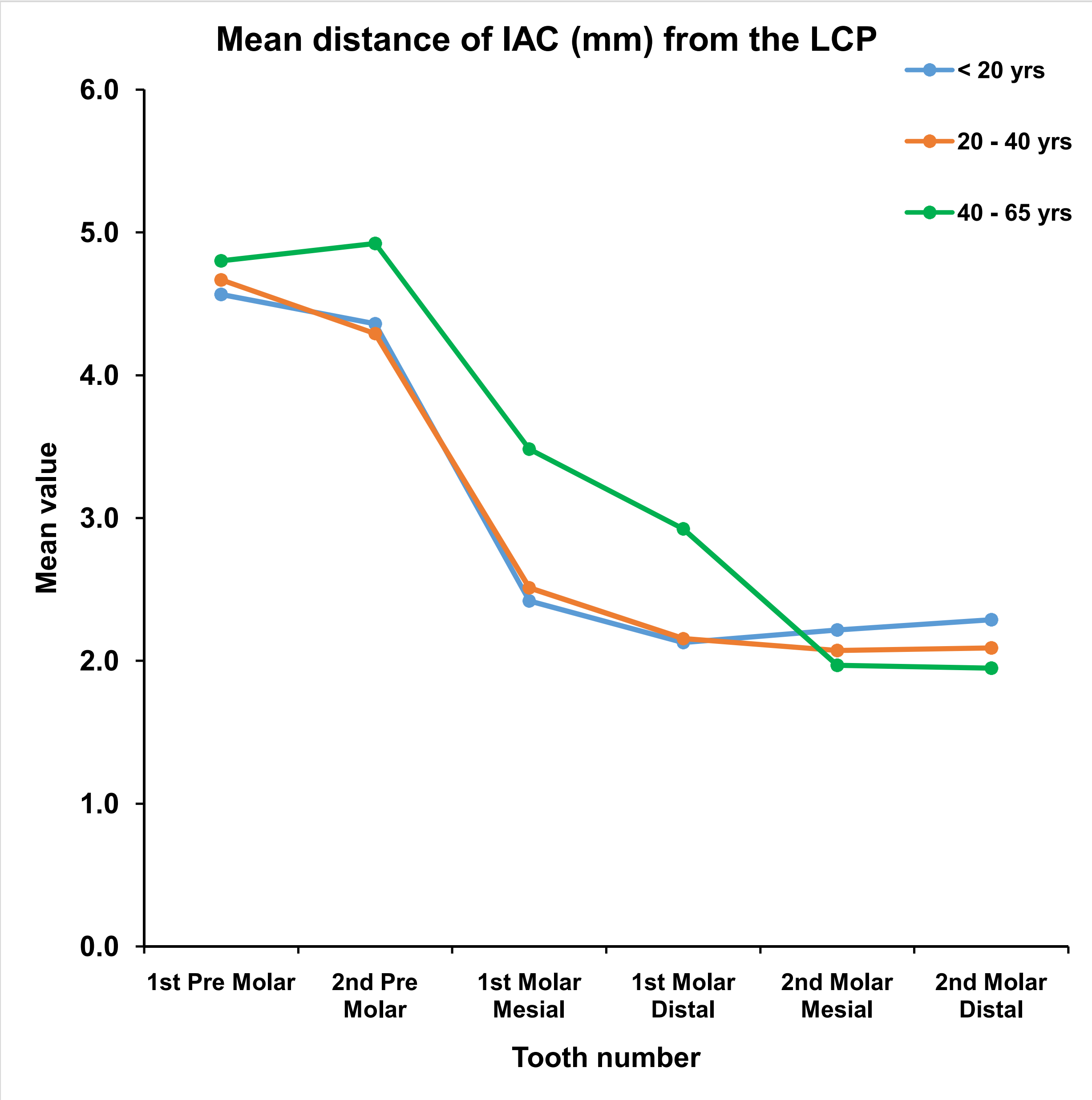
Distances	Group	N	Mean	Std. Dev	F-Value	P-Value
Distance of IAC (mm) from the LCP - 1st Pre Molar	< 20 yrs	60	4.5655	.85306	.797	.452
	20 - 40 yrs	60	4.6688	1.13107		
	40 - 65 yrs	60	4.8008	1.06628		
	Total	180	4.6784	1.02255		
Distance of IAC (mm) from the LCP - 2nd Pre Molar	< 20 yrs	60	4.3602	.98779	6.543	.002
	20 - 40 yrs	60	4.2925	1.01610		
	40 - 65 yrs	60	4.9233	1.13658		
	Total	180	4.5253	1.08080		
Distance of IAC (mm) from the LCP - 1st Molar Mesial	< 20 yrs	60	2.4203	1.02819	13.228	<0.001
	20 - 40 yrs	60	2.5120	.96419		
	40 - 65 yrs	60	3.4828	1.65226		
	Total	180	2.8051	1.33682		
Distance of IAC (mm) from the LCP - 1st Molar Distal	< 20 yrs	60	2.1292	1.05680	10.124	<0.001
	20 - 40 yrs	60	2.1562	.72045		
	40 - 65 yrs	60	2.9247	1.41125		
	Total	180	2.4033	1.15431		

Distance of IAC (mm) from the LCP - 2nd Molar Mesial	< 20 yrs	60	2.2175	.99678	1.290	.278
	20 - 40 yrs	60	2.0733	.82811		
	40 - 65 yrs	60	1.9697	.69453		
	Total	180	2.0868	.85023		
Distance of IAC (mm) from the LCP - 2nd Molar Distal	< 20 yrs	60	2.2890	.97336	2.162	.118
	20 - 40 yrs	60	2.0922	.79730		
	40 - 65 yrs	60	1.9493	.91545		
	Total	180	2.1102	.90418		

INFERENCE:

Mean value showing the canal close to LCP in the region of second molar (2.08 mm mesial root, 2.11 mm distal root). With increase in age the distance from lingual cortical plate to IAC increased in the region of premolars and first molar and decreased in the region of second molar

GRAPH 2: Mean distance of IAC from LCP between age groups



b) ANOVA Table

Distances	Sum of Squares		df	Mean Square	F-Value	P-Value
Distance of IAC (mm) from the LCP - 1st Pre Molar	Between Groups	1.670	2	.835	.797	.452
	Within Groups	185.496	177	1.048		
	Total	187.165	179			
Distance of IAC (mm) from the LCP - 2nd Pre Molar	Between Groups	14.394	2	7.197	6.543	.002
	Within Groups	194.700	177	1.100		
	Total	209.094	179			
Distance of IAC (mm) from the LCP - 1st Molar Mesial	Between Groups	41.597	2	20.798	13.228	<0.001
	Within Groups	278.291	177	1.572		
	Total	319.887	179			
Distance of IAC (mm) from the LCP - 1st Molar Distal	Between Groups	24.483	2	12.241	10.124	<0.001
	Within Groups	214.023	177	1.209		
	Total	238.506	179			
Distance of IAC (mm) from the LCP - 2nd Molar Mesial	Between Groups	1.859	2	.930	1.290	.278
	Within Groups	127.540	177	.721		
	Total	129.399	179			
Distance of IAC (mm) from the LCP - 2nd Molar Distal	Between Groups	3.490	2	1.745	2.162	.118
	Within Groups	142.849	177	.807		
	Total	146.339	179			

C) Tukey HSD Post Hoc Tests for Multiple Comparisons

Dependent Variable	Group		Mean Difference	P-Value
Distance of IAC (mm) from the LCP - 2nd Pre Molar	< 20 yrs	20 - 40 yrs	.06767	.934
		40 - 65 yrs	-.56317	.010
	20 - 40 yrs	40 - 65 yrs	-.63083	.003
Distance of IAC (mm) from the LCP - 1st Molar Mesial	< 20 yrs	20 - 40 yrs	-.09167	.915
		40 - 65 yrs	-1.06250	<0.001
	20 - 40 yrs	40 - 65 yrs	-.97083	<0.001
Distance of IAC (mm) from the LCP - 1st Molar Distal	< 20 yrs	20 - 40 yrs	-.02700	.990
		40 - 65 yrs	-.79550	<0.001
	20 - 40 yrs	40 - 65 yrs	-.76850	.001

TABLE 3:

a) To compare mean values between age groups. – Inferior BM

One way ANOVA to compare mean values between age groups. – Inferior BM

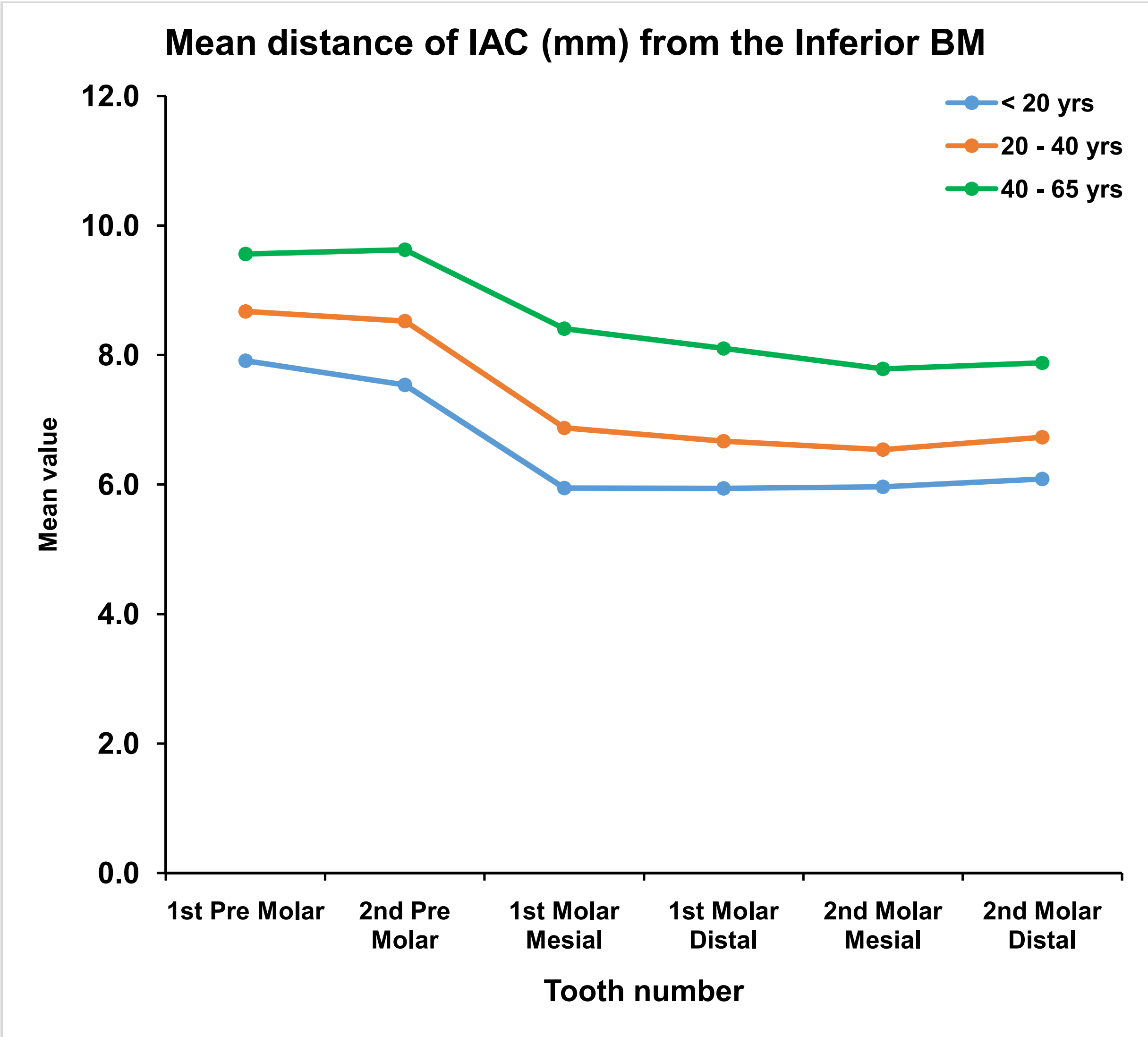
Distances	Group	N	Mean	Std. Dev	F-Value	P-Value
Distance of IAC (mm) from the Inferior BM - 1st Pre Molar	< 20 yrs	60	7.9140	1.75150	18.071	<0.001
	20 - 40 yrs	60	8.6767	1.45643		
	40 - 65 yrs	60	9.5623	1.26077		
	Total	180	8.7177	1.64026		
Distance of IAC (mm) from the Inferior BM - 2nd Pre Molar	< 20 yrs	60	7.5382	1.81365	23.771	<0.001
	20 - 40 yrs	60	8.5257	1.86467		
	40 - 65 yrs	60	9.6290	1.23204		
	Total	180	8.5643	1.86118		
Distance of IAC (mm) from the Inferior BM - 1st Molar Mesial	< 20 yrs	60	5.9468	1.71167	40.364	<0.001
	20 - 40 yrs	60	6.8762	1.47547		
	40 - 65 yrs	60	8.4093	1.33758		
	Total	180	7.0774	1.81924		
Distance of IAC (mm) from the Inferior BM - 1st Molar Distal	< 20 yrs	60	5.9425	1.87420	29.699	<0.001
	20 - 40 yrs	60	6.6738	1.36837		
	40 - 65 yrs	60	8.1018	1.38744		
	Total	180	6.9061	1.79389		

Distance of IAC (mm) from the Inferior BM - 2nd Molar Mesial	< 20 yrs	60	5.9672	2.27696	14.140	<0.001
	20 - 40 yrs	60	6.5418	1.68501		
	40 - 65 yrs	60	7.7858	1.72567		
	Total	180	6.7649	2.05076		
Distance of IAC (mm) from the Inferior BM - 2nd Molar Distal	< 20 yrs	60	6.0867	2.25469	11.317	<0.001
	20 - 40 yrs	60	6.7343	1.87754		
	40 - 65 yrs	60	7.8775	2.11388		
	Total	180	6.8995	2.20490		

INFERENCE:

Mean value showing the distance of IAC from inferior border of mandible increases with increase in age and is statistically significant (<0.001).

GRAPH 3: Mean distance of IAC from Inferior BM between age groups



b) ANOVA Table

Distances	Sum of Squares		df	Mean Square	F-Value	P-Value
Distance of IAC (mm) from the Inferior BM - 1st Pre Molar	Between Groups	81.661	2	40.831	18.071	<0.001
	Within Groups	399.931	177	2.259		
	Total	481.592	179			
Distance of IAC (mm) from the Inferior BM - 2nd Pre Molar	Between Groups	131.282	2	65.641	23.771	<0.001
	Within Groups	488.771	177	2.761		
	Total	620.052	179			
Distance of IAC (mm) from the Inferior BM - 1st Molar Mesial	Between Groups	185.563	2	92.782	40.364	<0.001
	Within Groups	406.861	177	2.299		
	Total	592.424	179			
Distance of IAC (mm) from the Inferior BM - 1st Molar Distal	Between Groups	144.735	2	72.368	29.699	<0.001
	Within Groups	431.291	177	2.437		
	Total	576.026	179			
Distance of IAC (mm) from the Inferior BM - 2nd Molar Mesial	Between Groups	103.707	2	51.853	14.140	<0.001
	Within Groups	649.102	177	3.667		
	Total	752.809	179			
Distance of IAC (mm) from the Inferior BM - 2nd Molar Distal	Between Groups	98.668	2	49.334	11.317	<0.001
	Within Groups	771.560	177	4.359		
	Total	870.227	179			

C)_Tukey HSD Post Hoc Tests for Multiple Comparisons

Dependent Variable	Group		Mean Difference	P-Value
Distance of IAC (mm) from the Inferior BM - 1st Pre Molar	< 20 yrs	20 - 40 yrs	-.76267	.017
		40 - 65 yrs	-1.64833	<0.001
	20 - 40 yrs	40 - 65 yrs	-.88567	.004
Distance of IAC (mm) from the Inferior BM - 2nd Pre Molar	< 20 yrs	20 - 40 yrs	-.98750	.004
		40 - 65 yrs	-2.09083	<0.001
	20 - 40 yrs	40 - 65 yrs	-1.10333	.001
Distance of IAC (mm) from the Inferior BM - 1st Molar Mesial	< 20 yrs	20 - 40 yrs	-.92933	.003
		40 - 65 yrs	-2.46250	<0.001
	20 - 40 yrs	40 - 65 yrs	-1.53317	<0.001
Distance of IAC (mm) from the Inferior BM - 1st Molar Distal	< 20 yrs	20 - 40 yrs	-.73133	.030
		40 - 65 yrs	-2.15933	<0.001
	20 - 40 yrs	40 - 65 yrs	-1.42800	<0.001
Distance of IAC (mm) from the Inferior BM - 2nd Molar Mesial	< 20 yrs	20 - 40 yrs	-.57467	.230
		40 - 65 yrs	-1.81867	<0.001
	20 - 40 yrs	40 - 65 yrs	-1.24400	.001
Distance of IAC (mm) from the Inferior BM - 2nd Molar Distal	< 20 yrs	20 - 40 yrs	-.64767	.208
		40 - 65 yrs	-1.79083	<0.001
	20 - 40 yrs	40 - 65 yrs	-1.14317	.009

TABLE 4:

a) To compare mean values between age groups. – Tooth Apex

One way ANOVA to compare mean values between age groups. – Tooth Apex

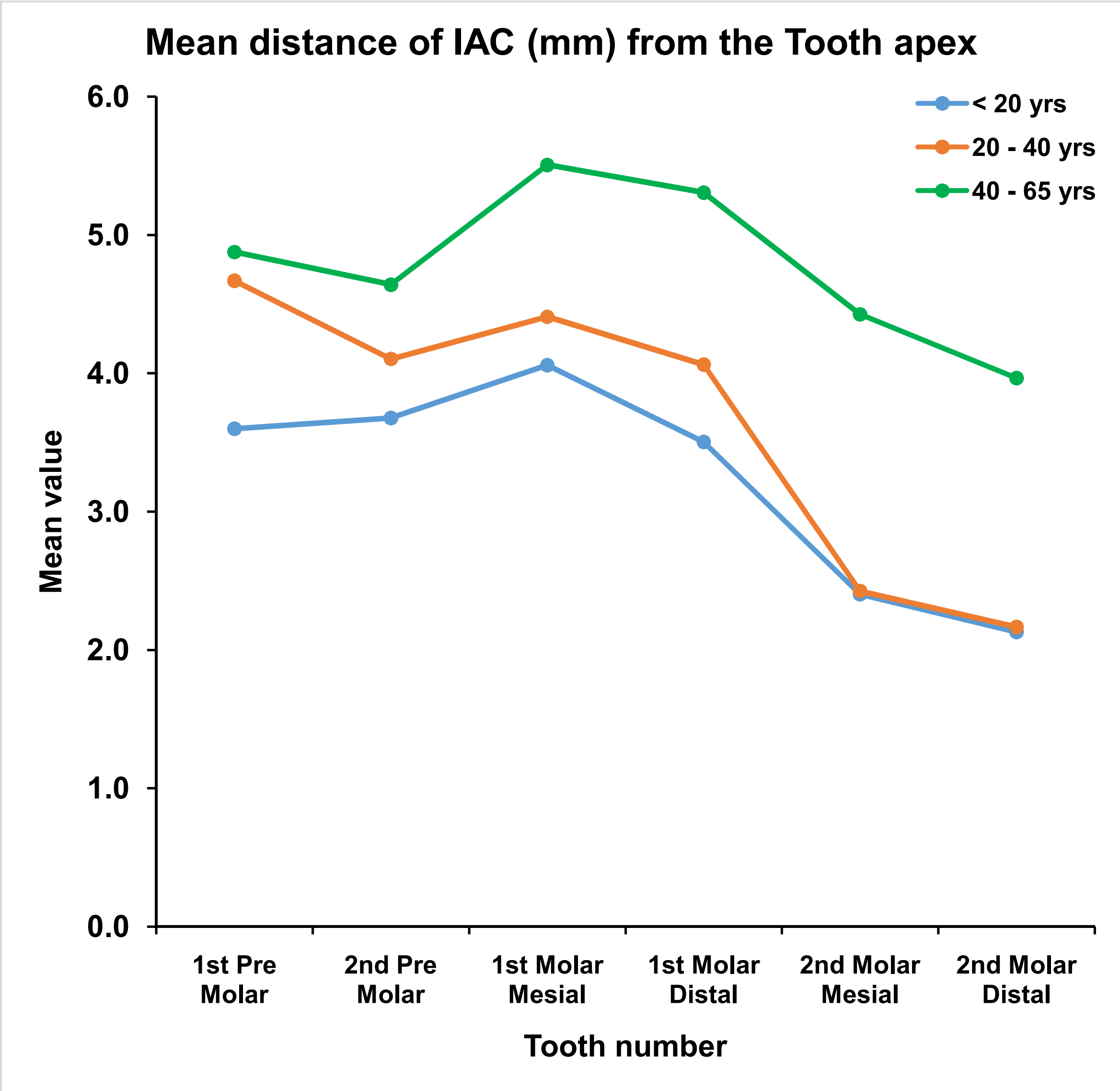
Distances	Group	N	Mean	Std. Dev	F-Value	P-Value
Distance of IAC (mm) from the Tooth apex - 1st Pre Molar	< 20 yrs	60	3.5992	2.18887	6.025	.003
	20 - 40 yrs	60	4.6693	2.41067		
	40 - 65 yrs	60	4.8770	1.85582		
	Total	180	4.3818	2.22375		
Distance of IAC (mm) from the Tooth apex - 2nd Pre Molar	< 20 yrs	60	3.6762	2.45899	2.404	.093
	20 - 40 yrs	60	4.1042	2.78795		
	40 - 65 yrs	60	4.6407	1.91479		
	Total	180	4.1403	2.43311		
Distance of IAC (mm) from the Tooth apex - 1st Molar Mesial	< 20 yrs	60	4.0585	2.52155	6.485	.002
	20 - 40 yrs	60	4.4085	2.09121		
	40 - 65 yrs	60	5.5067	2.26206		
	Total	180	4.6579	2.36780		
Distance of IAC (mm) from the Tooth apex - 1st Molar Distal	< 20 yrs	60	3.5027	2.75451	8.937	<0.001
	20 - 40 yrs	60	4.0633	2.11508		
	40 - 65 yrs	60	5.3060	2.25719		
	Total	180	4.2907	2.49514		
Distance of IAC (mm)	< 20 yrs	60	2.4025	2.48361	15.739	<0.001

from the Tooth apex - 2nd Molar Mesial	20 - 40 yrs	60	2.4260	2.32308		
	40 - 65 yrs	60	4.4265	1.96787		
	Total	180	3.0850	2.44812		
Distance of IAC (mm) from the Tooth apex - 2nd Molar Distal	< 20 yrs	60	2.1295	2.26869	13.743	<0.001
	20 - 40 yrs	60	2.1652	2.04934		
	40 - 65 yrs	60	3.9650	2.25429		
	Total	180	2.7532	2.34399		

INFERENCE:

Mean value showing the distance of IAC from root apex increases with increase in age.

GRAPH 4: Mean distance of IAC from Tooth apex between age groups



b) _ANOVA Table

Distances	Sum of Squares		df	Mean Square	F-Value	P-Value
Distance of IAC (mm) from the Tooth apex - 1st Pre Molar	Between Groups	56.425	2	28.212	6.025	.003
	Within Groups	828.744	177	4.682		
	Total	885.169	179			
Distance of IAC (mm) from the Tooth apex - 2nd Pre Molar	Between Groups	28.026	2	14.013	2.404	.093
	Within Groups	1031.657	177	5.829		
	Total	1059.683	179			
Distance of IAC (mm) from the Tooth apex - 1st Molar Mesial	Between Groups	68.513	2	34.257	6.485	.002
	Within Groups	935.046	177	5.283		
	Total	1003.559	179			
Distance of IAC (mm) from the Tooth apex - 1st Molar Distal	Between Groups	102.212	2	51.106	8.937	<0.001
	Within Groups	1012.190	177	5.719		
	Total	1114.401	179			
Distance of IAC (mm) from the Tooth apex - 2nd Molar Mesial	Between Groups	161.983	2	80.991	15.739	<0.001
	Within Groups	910.818	177	5.146		
	Total	1072.800	179			
Distance of IAC (mm) from the Tooth apex - 2nd Molar Distal	Between Groups	132.195	2	66.097	13.743	<0.001
	Within Groups	851.287	177	4.810		
	Total	983.482	179			

c) Tukey HSD Post Hoc Tests for Multiple Comparisons

Dependent Variable	Group		Mean Difference	P-Value
Distance of IAC (mm) from the Tooth apex - 1st Pre Molar	< 20 yrs	20 - 40 yrs	-1.07017	.020
		40 - 65 yrs	-1.27783	.004
	20 - 40 yrs	40 - 65 yrs	-.20767	.859
Distance of IAC (mm) from the Tooth apex - 1st Molar Mesial	< 20 yrs	20 - 40 yrs	-.35000	.682
		40 - 65 yrs	-1.44817	.002
	20 - 40 yrs	40 - 65 yrs	-1.09817	.026
Distance of IAC (mm) from the Tooth apex - 1st Molar Distal	< 20 yrs	20 - 40 yrs	-.56067	.406
		40 - 65 yrs	-1.80333	<0.001
	20 - 40 yrs	40 - 65 yrs	-1.24267	.014
Distance of IAC (mm) from the Tooth apex - 2nd Molar Mesial	< 20 yrs	20 - 40 yrs	-.02350	.998
		40 - 65 yrs	-2.02400	<0.001
	20 - 40 yrs	40 - 65 yrs	-2.00050	<0.001
Distance of IAC (mm) from the Tooth apex - 2nd Molar Distal	< 20 yrs	20 - 40 yrs	-.03567	.996
		40 - 65 yrs	-1.83550	<0.001
	20 - 40 yrs	40 - 65 yrs	-1.79983	<0.001

Previous researchers have examined the path of the Inferior alveolar nerve in cadaver studies. Yet other studies have attempted to determine the course of the Inferior alveolar nerve through radiographic means instead of purely relying on cadaver dissections. [33] Many of these studies, however, suffer from a small sample sizes and the results may not be generalized to the population at large. On the other hand, most such studies have noted that the canal and consequently the nerve do not maintain a constant position in the mandible, specifically in relation to roots of the lower teeth. Such variability may then lead to unpredictable anatomic encounters at the time of surgery.

More recently, complex 3D imaging such as computed tomography has been utilized to establish the path of the Inferior alveolar canal as well as other anatomic landmarks. These cross-sectional imaging techniques offers more detailed information to the clinician in 3D through interactive manipulation of the volume, thus providing an effective tool for diagnosis and treatment planning. [60] These studies have generally focused on the configuration of the Inferior alveolar canal with respect to anatomic landmarks other than the roots of teeth, such as the buccal or lingual cortical plates or the canal path within the ramus as opposed to the body of the mandible where the roots lie. However, in endodontic applications, the relationship of the Inferior alveolar canal and its contents to the apices of teeth is important to adequately plan for periapical surgical procedures.

The results of this study indicated the general course of the Inferior alveolar canal, in relation to the buccal, lingual, inferior border of mandible and root apex, as it courses posteriorly from the distal root of the mandibular second molar to the premolar region.

Our results confirm the findings of previous investigators who dissected cadaver jaws to study the course of the canal. The proximity of the canal to the buccal cortical plate in the region of the first and second premolar corresponds to the mental foramen. The canal was found to be closer to the lingual cortical plate and the inferior border of mandible in the region of the second molars.

These observations in our study were similar to the study done by Nair and associates using Cone beam computed tomography in 2013. [53]

Kamburoglu and associates noted that CBCT boasts of much higher accuracy than that of calipers. In investigating the position of the canal around the mandibular first molars, they concluded after evaluating 50 patients with intact dentition that IAC is positioned about 4.9 mm from the buccal cortical bone. Our study with 90 samples showed a slightly higher value of 5.01 mm from mesial root and 5.55 mm (Table 1)from distal roots of first molar to buccal cortical plate. [44]

Nkenke and associates reported that the distance from the upper alveolar crest to the inferior alveolar nerve canal in the retromolar area was 11.0±2.2 mm. [61] Levine et al. measured 17.4 mm around the mandibular second molar area. In the above mentioned studies the root apex was not considered as in our study. [40]

The anatomical position of the inferior alveolar nerve canal appears to differ by age. According to Levine et al. in older patients, the distance from the outer buccal cortical bone to the inferior alveolar nerve canal was shorter. [40] Our study showed that the distance of inferior alveolar canal to the outer aspect of buccal cortical plate was shorter in 40-65 yr group in the region of premolars and first molars, but no significant differences were observed in the region of second molars with increase in age. The knowledge on the thickness of buccal cortical plate in the region of mandibular molars plays a significant role in planning various orthognathic surgical procedures and implant dentistry.

This study sought to contribute to decreased the incidence rates of nerve injury during bone harvesting, mandibular body osteotomy, anterior extent of bilateral saggital split oseteotomy, and implant placement to improve the understanding of anatomical structure of the inferior alveolar canal, and to simplify measurement of the distance between the exterior buccal cortex and Inferior alveolar canal.

In our study the inferior alveolar canal was close to LCP in the region of second molar (2.08 mm mesial root, 2.11 mm distal root)(Table 2). With increase in age the distance from lingual cortical plate to IAC increased in the region of premolars and first molar and decreased in the region of second molar. In most of the cases (80%), the observed pattern is the canal running close to lingual cortical plate in the region of second molar and first molar and it moves buccally just anterior to mesial root of first molars. In 2.2% of cases the canal moves between the roots of first molar buccally and in 16.6% of cases the canal crosses buccally anterior to second premolar. Only in one case the canal was found entirely on the buccal aspect from the second molar till the mental foramen with respect to the roots of mandibular posterior teeth.

Similar findings was observed by Kim et al who classified the buccolingual location of the IAN into 3 types. Most cases (70%) were type 1, in which the IAN canal follows the lingual cortical plate of the mandibular ramus and body. In type 2 (15%), the IAN canal is located in the middle of the mandibular ramus posterior to the second molar. It then runs lingually to follow the lingual plate. In type 3 (15%), the IAN canal is located near the middle of the ramus and body. [47] This study does not give the details on crossing over of IAC from buccal side to lingual side which is of great value to the clinician regarding implant placement in the region of first molar and second premolar, the common site for implant placement.

The results of our study also showed that distance of IAC from inferior border of mandible increases with increase in age.

The mandibular canal harbours a thick nerve and vessels, typically located in close proximity to the root apices. [62] IAN injuries occur commonly following endodontic treatment of the mandibular molars and may be due to root-canal instrumentation that extends beyond the apical foramen to enter the mandibular canal or the forcing of root-filling material and inadequate debridement into the root and mandibular canal. [63] The inadvertent injection of irrigation solutions, especially sodium hypochlorite, beyond the apical foramen may also cause Inferior alveolar nerve injury leading to tissue necrosis. The extrusion of infected debris into the mandibular canal is another potential complication of root-canal treatment in mandibular molars with apical periodontitis. As reported previously, infected debris may breach the protective perineurium of the Inferior alveolar nerve and damage nerve conductivity. Compression arising from haematomas developing after injury to the wall or the mandibular canal contents may also result in complications, such as hypaesthesia, dysesthesia, hyperaesthesia, or complete anaesthesia. [64] Understanding the proximity of the mandibular canal and Inferior alveolar nerve to the apices of the mandibular molar roots is thus important during and after endodontic treatments. Accurate knowledge of inferior alveolar nerve location is essential for the prevention of iatrogenic errors.

M. LECKEL, B. KRESS and M. SCHMITTER in 2009 reported a case of Neuropathic pain resulting from implant placement because the canal was not clearly visualized in conventional dental radiographs, this uncharacteristic situation made correct diagnosis difficult and led to unnecessary surgical extraction of adjacent teeth. In this case, Computed tomography (CT) finally revealed the close proximity of the apex of the implant and the bony structure of the mandibular canal. The effect on the nervus alveolaris inferior was also demonstrated using an innovative high-resolution dental magnetic-resonance-imaging technique reflecting vascular reactions of the neurovascular bundle after potentially damaging surgical intervention. After removal of the causative implant, the pain gradually faded over a period of a year. [65]

J. Lo´ pez-Lo´ pez, A. Estrugo-Devesa, E. Jane´ -Salas and J. J. Segura-Egea in 2011 reported a case of pain and paraesthesia due to endodontic sealer (AH Plus) penetration within the mandibular canal after root canal treatment. This case illustrates the care required when performing root canal treatment, especially when the root apices are in close proximity to the inferior alveolar nerve canal. [66]

The present study found that the distance from the Inferior alveolar canal to the root apices was significantly shorter in patients of both genders aged <20 (mean distance 3.59 mm in 1st premolar, 3.67 mm in 2nd premolar, 4.05, 3.05 mm in 1st molar mesial and distal roots, 2.40, 2.12 in 2nd molar mesial and distal roots), and the distance increased in 20-40, 40-65 year groups (mean distance 4.66 mm in 1st premolar, 4.10 mm in 2nd premolar, 4.40, 4.06 mm in 1st molar mesial and distal roots, 2.42, 2.12 in 2nd molar mesial and distal roots) in 20-40 year group and (mean distance 4.87 mm in 1st premolar, 4.64 mm in 2nd premolar, 5.50, 5.30 mm in 1st molar mesial and distal roots, 4.42, 3.96 mm in 2nd molar mesial and distal roots in 40-65 year group (Table 4).

These findings could be explained by continued mandibular growth up to age 40 in females and age 50 in males. Another possibility might be due to continued tooth eruption throughout life as a result of attrition and wear. It is noteworthy that several studies have now shown that the craniofacial complex continues to change and adapt throughout life and into the sixth decade. [67,68]

Love et al. and Foley & Mamandras studied facial skeletal growth during late adolescence in males and females and reported that AFH increased over the observation period. Between the ages of 18 and 50 years, anterior facial height increases about 22% more in males than in females (2.2 and 1.8mm, respectively); after the age of 50 years, vertical growth cessation rates increase. The findings of these investigations explain the shorter distance from the Inferior alveolar canal to the root apices found among individuals in <20 age group compared to the older age groups. [69, 70]

Swasty and associates showed that subjects who are 10–19 years old have thinner cortical bone and decreased mandibular height compared with all other age groups, with peak thickness in subjects 40–49 years old followed by a decrease in thickness after this period. [67]

The distance of IAC from root apex in our study was similar to the results obtained from a recent study by Nair, et al using CBCT scans in 44 patients in the age group of 18-70 years. [53]

The canal was also closest to the distal root of the second molar (2.75 mm) and farthest (4.65 mm) from first molar mesial root, although the distance from the roots of other teeth did not follow a set pattern. This was again similar to the results of other studies

Our study found that the distance between the Inferior alveolar canal and the root apices of mandibular first molars is significantly shorter in females than in males. This was similar to a study done by Simonton JD and associates where the distance between the Inferior alveolar canal and the root apices of mandibular first molar was shorter in females than males. [71]

In 30 teeth, the Inferior alveolar canal was in direct contact with the root apex. According to the present results 19 mandibular 2nd molar had direct contact with root apex, In 2 patients, the distal root was the only root contacting the IAC.

13 second molar in which Inferior alveolar canal was in direct contact were in <20 year group.

Similar results were obtained by a study done by Chong B. S, Quinn. A, R. R. Pawar, J. Makdissi & S. K. Sidhu, in which 50% of the mandibular second molar evaluated, there was an intimate relationship between the roots and the Inferior alveolar nerve. [72] But the study did not evaluate the relationship of Inferior alveolar canal with root apex of other teeth, also the age of the patient was not considered as in our study. The results suggested that second molar is the tooth most prone for nerve injury. Hence, the accurate determination of canal working length is not only essential to root canal treatment outcome but paramount to avoiding the risk of nerve injury, especially in cases where an intimate relationship exists between the roots and the Inferior alveolar nerve.

In 2 patients Inferior alveolar canal was in direct contact with root of 1st molar, this observation was concurrent to a study done by Simonton JD and associates in which 3% of patients in their study had the Inferior alveolar canal directly contacting 1 or both of the roots of the mandibular first molar. [71]

Another significant finding in our study was the presence of the neurovascular bundle at the level of the mandibular canine in 28 out of the 90 CBCT scans studied. This observation was similar to the results obtained by Nair and associates, in which 32.95% of the 44 scans showed canal at the level of the canine. [53]

The inferior alveolar canal is a critical anatomic structure whose course and location can often influence the treatment planning of different surgical procedures on the mandibular premolar, molar region. Therefore, awareness of the relationships and distance between IAC and the buccal cortical plate, lingual cortical plate, inferior border of mandible and tooth apex could be a significant factor in minimizing nerve injuries. Age related variation in these measurements should be appreciated before undertaking advanced surgical and non-surgical procedures of the mandibular premolars and molars.

Based on the results of this study, an important consideration in presurgical planning is that the position of inferior alveolar canal will not stay constant throughout a person’s lifetime. Moreover, the description of the course of the inferior alveolar canal and its anatomical relations by means of cone beam computed tomography can contribute significantly to clinical and surgical planning in different areas of Dentistry. Cone beam computed tomography (CBCT), a relatively new imaging modality in dentistry, produces high-resolution, artifact-free, superimposition-free, undistorted and non-magnified 3D images of the dental and maxillofacial anatomy that can be reformatted in any desired plane for interactive viewing and image manipulation.

1. Shankland WE. The position of the mental foramen in Asian Indians. J Oral Implantol 1994;20:118-123.

2. Sawyer DR, Kiely ML, Pyle MA. The frequency of accessory mental foramina in four Ethnic groups. Arch Oral Biol 1998;43:417-420.

3. Bavitz JB, Harn SD, Hansen CA, Lang M. An anatomical study of mental neurovascular bundle-implant relationships. Int J Oral Maxillofac Implants 1993;8:563- 567.

4. Fishel D, Buchner A, Hershkowith A, Kaffe I. Roentgenologic study of the mental Foramen. Oral Surg Oral Med Oral Pathol 1976;41:682-686.

5. Greenstein G, Tarnow D. The mental foramen and nerve: clinical and anatomical Factors related to dental implant placement: a literature review. J Periodontol 2006;77:1933-1943.

6. Kositbowornchai S, Densiri-aksorn W, Piumthanaroj P. Ability of two radiographic Methods to identify the closeness between the mandibular third molar root and the Inferior alveolar canal: a pilot study. Dentomaxillofac Radiol 2010;39:79-84.

7. Ludlow JB, Ivanovic M. Comparative dosimetry of dental CBCT devices and 64-slice CT for oral and maxillofacial radiology. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008;106:106-114.

8. Scarfe WC, Farman AG. What is cone-beam CT and how does it work? Dent Clin North Am 2008;52:707-30, v.

9. Baba R, Konno Y, Ueda K, Ikeda S. Comparison of flat-panel detector and image intensifier detector for cone-beam CT. Comput Med Imaging Graph 2002;26:153-158.

10. Baba R, Ueda K, Okabe M. Using a flat-panel detector in high resolution cone beam CT for dental imaging. Dentomaxillofac Radiol 2004;33:285-290.

11. Sukovic P. Cone beam computed tomography in craniofacial imaging. Orthod Craniofac Res. 2003;31(6):179-82

12. AAE & AAOMR. Use of cone-beam computed tomography in endodontics Joint Position Statement of the American Association of Endodontists and the American Academy of Oral and Maxillofacial Radiology. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2011;111:234-237.

13. Angelopoulous C, Thomas SL, Hechler S, Parissis N, Hlavacek M. Comparison between digital panoramic radiography and cone-beam computed tomography for the identification of the mandibular canal as part of presurgical dental implant assessment. J Oral Maxillofac Surg. 2008;66:2130-5.

14. Naitoh M, Nakahara K, Suenaga Y, Gotoh K, kondos, Ariji E. Comparison between Cone-beam and multislice computed tomography depicting mandibular neurovascular Canal structures. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2010;109:25-31.

15. Robb RA. The dynamic spatial reconstructor: an x-ray video-fluoroscopic CT scanner for dynamic volume imaging of moving organs. IEEE Trans Med Imaging 1982;1:22–33

16. Jaffray DA, Drake DG, Moreau M, et al. A radiographic and tomographic imaging system integrated into a medical linear accelerator for localization of bone and soft-tissue targets. Int J Radiat Oncol Biol Phys 1999;45:773–89

17. Ludlow JB, Davies-Ludlow LE, Mol A. Dosimetry of recently introduced CBCT units for oral and maxillofacial radiology. In: Proceedings of the16th International Congress of Dentomaxillofacial Radiology, Beijing, China. 2007; 26(30): 97

18. Feldkamp LA, Davis LC, Kress JW. Practical cone-beam algorithm. J Opt Soc Am 1984;A1(6):612–9.

19. Faisal A. Quereshy, Truitt A. Savell and J. Martin Palomo. Applications of Cone Beam Computed Tomography in the Practice of Oral and Maxillofacial Surgery. J Oral Maxillofac Surg 2008, 66:791-796.

20. CM Ziegler, R Woertche, J Brief and S Hassfeld. Clinical indications for digital volume tomography in oral and maxillofacial surgery. Dentomaxillofacial Radiology 2002; 31: 126- 130.

21. S.K. Mukherji A.C. Miracle. Conebeam CT of the Head and Neck, Part-2: Clinical Applications. Am J Neuroradiology 2009; 30: 1285–92.

22. E Hirsch, U Wolf, F Heinicke and MAG Silva, Dosimetry of the cone beam computed tomography Veraviewepocs 3D compared with the 3D Accuitomo in different fields of view. Dentomaxillofacial radiology 2008; 37: 268–273.

23. Mozzo P, Procacci C, Tacconi A, et al. A new volumetric CT machine for dental imaging based on the cone-beam technique: preliminary results. Eur Radiol 1998; 8: 1558–1564.

24. Y. Arai, E Tammisalo, K Iwai, K Hashimoto, and K Shinoda, Development of a compact, Computed Tomographic apparatus for dental use. Dentomaxillofacial radiology 1999; 28: 245-248.

25. Mah J, Hatcher D: Three-dimensional craniofacial imaging. Am J Orthod Dentofac Orthop 2004;126:308.

26. Palomo JM, Kau CH, Bahl Palomo L, et al: Three-dimensional cone beam computerized tomography in dentistry. Dent Today. 2006;25:130.

27. M. Conhen, J. Kemper, O. Mobes, J. Pawelzik, U. Modder-Radiation dose in dental radiology. Eur.radiol 2002; 12: 634- 637.

28. Yasuhiro Morimoto et. Al. New Trends and Advances in Oral and Maxillofacial Imaging. Current Medical Imaging Reviews, 2009;5: 226-237.

29. Lindh C, Petersson A. Radiologic examination for location of the mandibular canal: a comparison between panoramic radiography and conventional tomography. Int J Oral Maxillofac Implants. 1989;4:249-53.

30. Denio D, Torabinejad M, Bakland LK. Anatomical relationshipof the mandibular canal to its surrounding structures in mature mandibles. J Endod. 1992;18:161-5.

31. Gowgiel JM. The position and course of the mandibular canal. J Oral Implantol. 1992;18:383-5.

32. Aung H H, Mustafa NS. Morphometric Analysis of the Mandibular Canal and Mental Foramen Using OPG and 3D CBCT: A Comparative Study. Int J Oral Maxillofac Surg. 1992; 21(2): 85-9.

33. Wadu SC, Penhall B, Townsend GC. Morphological variability of the human inferior alveolar nerve. Clin Anat. 1997;10:82–87

34. Neiva RF, Gapski R, Wang HL. Morphometric analysis of implant-related anatomy in Caucasian skulls. J Periodontol 2004;75:1061-1067.

35. Kobayashi K, Shimoda S, Nakagawa Y, Yamamoto A. Accuracy in measurement of distance using limited cone-beam computerized tomography. Int J Oral Maxillofac Implants. 2004;19:228-31.

36. Agthong S, Huanmanop T, Chentanez V. Anatomical variations of the supraorbital, infraorbital, and mental foramina related to gender and side. J Oral Maxillofac Surg 2005;63:800-804.

37. Paes Ada SF, Moreira CR, Sales MAO, Cavalcanti MGP. Comparative study of single and multislice computed tomography for assessment of the mandibular canal. J Appl Oral Sci. 2007;15:220-4.

38. Tantanapornkul W, Okouchi K, Fujiwara Y, Yamashiro M, Maruoka Y, Ohbayashi N, et al. A comparative study of cone-beam computed tomography and conventional panoramic radiography in assessing the topographic relationship between the mandibular canal and impacted third molars. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2007;103:253-9.

39. Weeraya, Okouchi K, Fujiwara Y, et al. A comparative study of cone-beam computed tomography and conventional panoramic radiography in assessing the topographic relationship between the mandibular canal and Impacted Third Molars. Oral Maxillofac Radiol 2007;103(2):253-9.

40. Levine MH, Goddard AL, Dodson TB. Inferior alveolar nerve canal position: a Clinical and radiographic study. J Oral Maxillofac Surg 2007;65:470-474.

41. Patel S, Dawood A, Ford TP, Whaites E. The potential applications of cone beam computed tomography in the management of endodontic problems. Int Endod J 2007;40:818-830.

42. Loubele M, Jacobs R, Maes F, Denis K, White S, Coudyzer W, et al. Image quality vs radioation dose of four cone beam computed tomography scanners. Dentomaxillofac Radiol. 2008;37:309-19.

43. Naitoh M, Katsumata A, Kubota Y, Hayashi M, Ariji E. Relationship between cancellous bone density and mandibular canal depiction. Implant Dent. 2009;18:112-8.

44. Kamburoğlu K, Kiliç C, Özen T, Yüksel SP. Measurements of mandibular canal region obtained by cone-beam computed tomography: a cadaveric study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009;107:e34-e42.

45. Lofthag-Hansen S, Gröndahl K, Ekestubbe A. Cone-beam CT for preoperative implant planning in the posterior mandible: visibility of anatomic landmarks. Clin Implant Dent Relat Res. 2009;11:246-55.

46. CHEN Q, Deng Gao LIU, Gang ZHANG, Xu Chen MA. Evaluation of the Relationship between the Impacted Mandibular Third Molar and the Inferior Alveolar Canal on Panoramic Radiograph. The Chinese Journal of Dental Research. 2009;12(1):37-43

47. Kim ST, Hu KS, Song WC, Kang MK, Park HD, Kim HJ. Location of the mandibular canal and the topography of its neurovascular structures. J Craniofac Surg. 2009;20:936–939.

48. Liang X, Jacobs R, Hassan B, Li L, Pauwels R, Corpas L, et al. A comparative evaluation of Cone Beam Computed Tomography (CBCT) and Multi-Slice CT (MSCT). Part I. On subjective image quality. Eur J Radiol. 2010;75(2):265-9.

49. Bothaina M. A'Akil, saadw. Al Bayatti. Radiographic determination of the distance of the mandibular third molar tooth to the inferior alveolar canal. J Bagh Coll Dentistry 2010;22(4):59-61.

50. Kyung-Hwan Kwon, Kyu-Bong Sim, Jae-Min Lee. Evaluation of the course of the inferior alveolar canal in the mandibular ramus using cone beam computed tomography. J Korean Assoc Oral Maxillofac Surg 2012;38:231-9.

51. Balaji SM, Krishnaswamy NR, Kumar SM, Rooban T. Inferior alveolar nerve canal position among South Indians: A cone beam computed tomographic pilot study. Ann Maxillofac Surg 2012;2:51-5.

52. Patil S, Matsuda Y, Nakajima K, Araki K, Okano T. Retromolar canals as observed on cone-beam computed tomography: their incidence, course, and characteristics. Oral and Maxillofac Radiol 2013;115(5):692-9.

53. Nair UP, Yazdi MH, Nayar GM, Parry H, Katkar RA, Nair MK. Configuration of the inferior alveolar canal as detected by cone beam computed tomography. J Conserv Dent 2013;16(6):518-21.

54. Sekerci AE, Sisman Y, Payveren MA. Retromolar canal as observed on cone-beam computed tomography: Report of two cases with clinical importance. J Oral Maxillofac Radiol 2013;1:86-9.

55. Xu G Z et al. Anatomic relationship between impacted third mandibular molar and the mandibular canal as the risk factor of inferior alveolar nerve injury. Br J Oral Maxillofac Surg 2013;51:215–19.

56. Yengar AR, Patil S, Nagesh KS, Mehkri S, Manchanda A. Detection of anterior loop and other patterns of entry of mental nerve into the mental foramen: A radiographic study in panoramic images. J Dent Implant 2013;3:21-5.

57. Shujaat S, Abouelkheir HM, Al-Khalifa KS, Al-Jandan B , Marei HF. Pre-operative assessment of relationship between inferior dental nerve canal and mandibular impacted third molar in Saudi population. The Saudi Dent J 2014;26:103–7.

58. Alabed Mela , Mohamed Abdel- Monem Tawfik , Noha Ahmed Mansour. Assessment of the Relationship between the Mandibular Canal and Impacted Third Molars Using Cone Beam Computed Tomography. Mansoura Journal of Dentistry 2014;1(3):49-55.

59. Jasa GR, Vizzotto MB, da Silveira PF, da Silveira HD, da Silveira HD, Correa LR, Raveca T. Buccal-lingual localization of the mandibular canal in relationship with the third molar using the lateral oblique technique. J Oral Maxillofac Radiol 2014;2:15-20.

60. Jacobs R, Mraiwa N, vansteenberghe D, Gijbels F, Quirynen M. Appearance, location, course, and morphology of the mandibular incisive canal: An assessment on spiral CT scan. Dentomaxillofac Radiol 2002;31:322-7.

61. Nkenke E, Radespiel-Troger M, Wiltfang J, Schultze-Mosgau S, Winkler G, Neukam FW. Morbidity of harvesting of retromolar bone grafts: a prospective study. Clin Oral Implants Res 2002;13: 514-21.

62. Carter RB, Keen EN. The intramandibular course of the inferior alveolar nerve. J Anat. 1971;108:433-40.

63. Escoda-Francoli J, Canalda-Sahli C, Soler A, Figueiredo R, Gay-Escoda C. Inferior alveolar nerve damage because of overextended endodontic material: a problem of sealer cement biocompatibility?. J Endod. 2007;33:1484-89.

64. Mohammadi Z. Endodontics-related paresthesia of the mental and inferior alveolar nerves: an updated review. J Can Dent Assoc. 2010;76:A117.

65. M. Leckel, B. Kress And M. Schmitter. Neuropathic pain resulting from implant placement: case report and diagnostic conclusions. Journal of Oral Rehabilitation 2009;36:543–546

66. Lo´ pez-Lo´ pez, A. Estrugo-Devesa, E. Jane´-Salas and J. J. Segura-Egea Inferior alveolar nerve injury resulting from overextension of an endodontic sealer: non-surgical management using the GABA analogue pregabalin. Int Endod J 2012;45(1):98-104.

67. Swasty D, Lee JS, Huang JC, et al. Anthropometric analysis of the human mandibular cortical bone as assessed by cone-beam computed tomography. J Oral Maxillofac Surg 2009;67:491–500.

68. Dager MM, mcnamara JA, Baccetti T, Franchi L. Aging in the craniofacial complex. Angle Orthod 2008;78:440–4.

69. Love RJ, Murray JM, Mamandras AH. Facial growth in males 16 to 20 years of age. Am J Orthod Dentofacial Orthop. 1990;97:200-6.

70. Foley TF, Mamandras AH. Facial growth in females 14 to 20 years of age. Am J Orthod Dentofacial Orthop. 1992;101:2

71. Simonton JD, Azevedo B, Schindler WG, Hargreaves KM. Age- and gender-related differences in the position of the inferior alveolar nerve by using cone beam computed tomography. J Endod. 2009;35:944-9.

72. Chong B. S, Quinn. A, R. R. Pawar, J. Makdissi & S. K. Sidhu The anatomical relationship between the roots of mandibular second molars and the inferior alveolar nerve. International Endodontic Journal. 2014;48(6):1-7.

ABSTRACT

INTRODUCTION

AIMS & OBJECTIVES

REVIEW OF LITERATURE

MATERIALS & METHODS

RESULTS & OBSERVATIONS

DISCUSSION

SUMMARY & CONCLUSION

ANNEXURES

FIGURES

BIBLIOGRAPHY

srlnum	Group	Distance of IAC (in mm) from the BCP						Distance of IAC (in mm) from the LCP						Distance of IAC (in mm) from the Inferior BM						Distance of IAC (in mm) from the Tooth apex					
		1st premolar	2nd premolar	1st molar mesial	1st molar distal	2 nd molar mesial	2nd molar distal	1st premolar	2nd premolar	1st molar mesial	1st molar distal	2 nd molar mesial	2nd molar distal	1st premolar	2nd premolar	1st molar mesial	1st molar distal	2 nd molar mesial	2nd molar distal	1st premolar	2nd premolar	1st molar mesial	1st molar distal	2 nd molar mesial	2nd molar distal
1F	1	4.16	4.16	6.01	6.01	6.5	6.5	4.44	4.44	1.64	1.71	1.37	1.37	8.74	8.74	6	6	5.7	5.7	0	0	3.33	2.3	0	0
2F	1	2.56	2.56	6.67	7.17	7.1	6.82	6.01	6.01	1.57	1.23	1.43	1.64	7.92	7.92	5.29	3.88	5.55	6.12	4.62	4.62	3.46	3.92	3.86	2.54
3F	1	3.41	3.41	4.78	4.92	3.28	3.28	3.69	3.69	2.53	2.8	1.84	1.84	5.6	5.6	3.92	3.84	1.38	1.38	4	4	3.95	2.89	3.9	3.9
4F	1	3.9	3.8	4.78	5.46	5.94	5.94	3.44	3.9	1.71	1.71	1.09	1.09	5.46	5.46	3.39	3.39	2.98	2.98	0	0	1	1	0	0
5M	1	4.73	4.73	7.65	9.34	10.12	10.12	5.5	5.5	2.14	1.36	1.37	1.37	7.72	7.72	7.78	8.51	12.56	12.56	3.35	3.35	3.33	2.7	0	0
6M	1	3.42	3.42	6.96	7.78	8.53	7.78	3.55	3.55	1.02	0.75	1.71	2.12	8.87	8.87	9.95	9.85	9.43	10.47	0	0	0	0	0	0
7M	1	1.64	1.64	6.14	6.89	6.48	6.48	4.16	4.16	1.02	0.69	1.64	1.64	12	12.33	8.51	8.59	8.11	8.11	2	2.32	6.35	5.56	2.53	2.53
8F	1	1.41	2.94	4.71	4.94	3.62	3	4.71	2.95	2.19	1.67	1.23	1.2	7.32	5.13	3.48	2.61	2.37	3.39	5.94	8.19	6.35	4.39	5.74	3.99
9F	1	3.14	3.14	4.78	5.26	4.07	4.07	5.05	5.05	4.78	5.26	4.84	4.84	7.41	7.41	6.01	6.03	5.8	5.8	0	0	2.3	1.43	0	0
10F	1	2.46	2.46	4.16	4.26	4.15	4.15	4.91	4.91	1.98	1.91	2.92	2.92	7.37	7.37	3.76	4.11	3.93	3.93	1.33	1.33	0.48	0.48	0	0
11F	1	2.46	2.46	5.12	4.26	4.3	4.15	4.91	4.91	1.3	1.91	1.98	2.92	7.37	7.37	3.97	4.11	3.88	3.93	1.33	1.33	1.67	0.48	0.68	0
12F	1	1.67	2.93	4.94	5.6	5.4	5.4	3.5	3.27	1.73	1.45	2.01	2.01	6.32	6.28	4.34	4.71	4.74	4.74	3.13	1.69	1.32	2.58	0	0
13M	1	1.3	1.3	3.96	4.68	4.6	4.95	3.33	3.33	4.29	2.95	2.9	2.85	9.35	9.35	6.8	6.5	6.25	6.25	3.86	3.86	3.57	3.32	5.19	4.37
14F	1	1.92	1.92	2.76	5.32	6.89	6.89	5.33	5.33	4.16	1.78	0.89	0.89	5.93	5.93	5.63	4.83	6.46	6.46	4.04	4.04	2.29	2.29	0	0
15M	1	2.23	2.23	3.32	5.06	4.73	4.46	4.67	4.67	4.28	3.06	3.7	3.64	7.26	7.26	6.1	5.4	5.38	5.84	8.11	8.11	10.9	11.17	10.18	8.34
16F	1	2.23	2.23	6.24	7	6.67	6.67	4.67	4.67	2.65	3.27	2.44	2.5	7.26	7.26	8.44	8.03	7.5	7.28	8.11	8.11	5.52	3.8	0.85	1.39
17F	1	3.34	3.34	6.28	5.73	7.54	7.5	5.34	5.34	2.05	3.14	2.74	2.78	9.8	9.8	6.52	6.48	6.32	6.55	4.47	4.47	4.4	3.58	1.89	1.31
18F	1	2.56	2.56	6.67	7.17	7.1	6.82	6.01	6.01	1.57	1.23	1.43	1.64	7.92	7.92	5.29	3.88	5.55	6.12	4.47	4.47	4.4	3.58	1.89	1.31
19F	1	3.41	3.41	4.78	4.92	3.28	3.28	3.69	3.69	2.53	2.8	1.84	1.84	5.6	5.6	3.92	3.84	1.38	1.38	4	4	3.95	1.89	3.9	3.9
20F	1	2.9	3.3	5.1	5.6	6.2	6.2	4.3	3.5	2.5	2.3	2	2.1	9.3	8.3	6.9	6.6	6.6	6.8	4.8	4.7	4.8	4.2	2.8	2.3
21F	1	4.73	4.73	7.65	9.34	10.12	10.12	5.5	5.5	2.14	1.36	1.37	1.37	7.72	7.72	7.78	8.51	12.36	12.56	3.35	3.35	3.33	2.7	0	0
22F	1	3.1	3.4	4.8	5.3	5.8	6	4.9	3.6	2.7	2	2	2.1	9.4	8.4	7.1	6.6	6.3	6.5	4.9	4.7	4.8	4.6	3.4	3
23M	1	3.42	3.42	6.96	7.78	8.53	7.78	3.55	3.55	1.02	0.69	1.64	1.64	12	12.44	8.51	8.59	8.11	8.11	2	2.23	6.35	5.56	2.53	2.53
24M	1	1.64	1.64	6.14	6.89	6.48	6.48	4.16	4.16	1.02	0.68	1.64	1.64	12	12.33	8.51	8.59	8.11	8.11	2	2.32	6.35	5.56	2.53	2.53
25M	1	3.1	3.4	4.8	5.3	5.8	6	4.9	3.6	2.7	2	2	2.1	9.4	8.4	7.1	6.6	6.3	6.5	4.9	4.7	4.8	4.6	3.4	3
26F	1	2.46	2.46	4.15	4.26	4.15	4.15	4.91	4.91	1.98	1.91	2.92	2.92	7.37	7.37	3.76	4.11	3.39	3.93	1.33	1.33	1.67	0.48	0.68	3.1
27F	1	2.46	2.46	5.12	4.26	4.3	4.15	4.19	4.81	1.3	1.91	1.98	2.93	7.37	7.36	3.97	4.11	3.88	3.93	1.33	1.69	1.67	0.48	0.68	3.2
28F	1	2.9	3.3	5.1	5.6	6.2	6.2	4.3	3.5	2.5	2.3	2	2.1	9.3	8.3	6.9	6.6	6.6	6.3	4.8	4.7	4.6	4.2	2.8	2.3
29F	1	1.92	1.92	2.7	5.32	6.86	6.89	5.3	5.3	4.16	1.78	0.89	0.89	5.93	5.93	5.63	4.83	6.46	6.46	4.04	4.04	2.29	2.29	1	1
30F	1	2.23	2.23	3.22	5.06	4.73	4.46	4.67	4.67	4.28	3.06	3.7	3.64	7.26	7.26	6.1	5.4	5.38	5.84	8.11	8.11	10.9	11.17	10.18	8.34
31M	2	2.8	3.02	3.2	4.62	5.86	7.36	6.83	4.58	4.15	2.41	1.93	1.99	8.88	8.41	6.97	6.78	6.46	7.73	9.02	8.84	9.62	8.47	7.24	5.74
32M	2	4.34	4.34	6.77	7.83	8.21	8.21	5.29	5.29	2.31	1.74	1.65	1.65	9.58	9.58	8.35	8.35	8.66	8.66	1.37	1.37	3.96	3.88	4.33	4.33
33M	2	2.95	2.95	5.96	6.19	6.92	6.92	4.27	4.27	0.98	1.04	1.64	1.86	8.88	9.26	8.12	6.66	5.25	4.86	4.77	2.62	5.25	6.99	4.24	3.03
34M	2	2.95	2.95	5.96	6.19	6.62	6.92	4.27	3.97	0.98	1.04	1.64	1.86	8.88	12.97	8.12	6.66	5.25	4.86	4.71	0.8	5.25	6.99	4.24	3.03
35F	2	3.43	4.82	7.47	7.47	6	6	5.7	3.78	2.16	2.16	1.96	1.96	7.44	6.16	5.79	5.79	4.59	4.59	5.26	1.36	3.82	3.82	0	0
36F	2	3.43	4.82	7.47	7.47	6	6	5.7	3.78	2.16	2.16	1.96	1.96	7.44	6.16	5.76	5.79	4.59	4.58	5.26	1.36	3.82	3.82	0	0
37F	2	4.46	4.46	7.47	7.47	7.63	7.63	5.18	5.18	2.16	2.16	1.96	1.96	7.44	6.16	5.76	5.79	4.58	4.58	10.47	10.47	3.82	3.82	5.2	5.2
38M	2	1.59	2.54	4.61	4.36	4.75	4.75	4.32	3.19	1.09	1.51	2.36	2.36	10.16	10.72	8.7	8.42	7.82	7.82	4.05	2.67	3.63	2.89	1.45	1.45
39M	2	1.26	1.26	4.61	4.36	6.24	5.64	8.36	8.36	1.09	1.51	2.42	2.57	10.16	10.72	8.7	8.42	7.82	5	7	7	3.63	2.89	7.79	6.17
40M	2	1.78	1.78	4.79	5.71	5.7	5.7	5.05	5.05	2.05	1.44	1.78	1.78	9.02	9.02	6.21	6.73	6.85	6.85	1.97	1.9	2.22	2.81	0	0

44F	2	4.78	4.78	6.31	6	5.93	6.09	4.03	4.03	2.35	2.08	3.24	2.77	6.53	6.53	6.07	5.62	6.69	7.14	1.86	1.86	1.75	1.51	2.17	0.31
45F	2	3.3	3.36	3.82	3.82	5.69	5.13	4.3	4.3	3.82	3.82	3.35	3.4	6.85	6.85	5.39	5.39	7.92	9.2	2.8	2.8	5.48	5.48	0.76	0.63
46M	2	3.5	3.4	5.28	5.28	5.81	6.56	3.52	3.52	3.21	3.21	3.2	3.14	6.81	6.81	5.88	5.88	6.53	7.24	8.5	8.5	8.5	8.5	5.27	4.32
47F	2	2.48	4.67	5.34	5.34	5.89	5.89	4.71	2.8	1.3	1.3	1.81	1.81	7.29	7.3	6.29	6.29	6.03	6.03	5.46	2.7	2.32	2.38	0.48	0.48
48F	2	2.48	4.67	5.34	5.34	5.89	5.89	4.71	2.8	1.3	1.3	1.81	1.81	7.29	7.3	6.29	6.29	6.03	6.03	5.46	2.7	2.32	2.38	0.48	0.48
49F	2	4.23	4.23	5.55	6.23	7.18	7.18	4.35	4.35	2.68	2.46	1.3	1.3	5.94	5.94	7.23	6.87	6.94	6.94	0.73	0.73	2.8	1.52	0	0
50F	2	2.32	2.32	5.22	6.21	7.18	7.18	4.17	4.17	3.91	2.93	1.3	1.3	7.64	7.64	5.85	6.46	6.94	6.94	3.35	3.35	5.05	3.91	0.48	0.48
51F	2	2.25	3.58	7.6	7.6	6	6	5.53	5.96	3.31	2	2	1.5	11.41	10.25	8.75	6.46	5	6	4.4	6.68	5	3	1	2
52F	2	1.91	1.91	3.28	3.28	4.85	4.85	4.23	4.23	2.13	2.13	2.36	1.54	11.99	11.99	5.21	5.21	3.07	3.07	6.91	6.91	5.05	3.91	0.48	0.48
53M	2	1.91	1.91	3.28	3.28	4.85	4.85	4.23	4.23	2.13	2.13	2.36	1.54	11.99	11.99	5.21	5.21	3.07	3.07	6.91	6.91	5.05	3.91	0.48	0.48
54F	2	4.03	4.03	4.27	5.81	7.24	7.58	5.88	5.88	3.84	2.4	1.52	1.03	10.03	10.03	10.1	9.86	8.73	8.64	3.88	3.88	2.33	2.75	0.81	1.52
55F	2	4.03	4.04	4.27	5.81	7.24	7.58	5.88	5.88	3.84	2.4	1.52	1.03	10.03	10.03	10.1	9.86	8.73	8.64	3.88	3.88	2.33	2.75	0.81	1.52
56M	2	3.43	4.82	7.47	7.47	6	6	0.7	3.78	2.16	2.16	1.96	1.96	7.44	6.16	5.76	5.79	4.59	4.58	5.26	1.36	3.82	3.82	1	1
57M	2	3.1	3.4	4.8	5.3	5.6	6	4.9	3.6	2.7	2	2	2.1	9.4	8.4	7.1	6.6	6.3	6.5	4.9	4.7	4.8	4.6	3.4	3
58F	2	3.3	3.36	3.82	3.83	5.69	5.19	4.3	4.3	3.82	3.82	3.35	3.4	6.85	6.85	5.9	5.39	7.92	9.2	2.8	2.8	5.48	5.48	0.76	0.63
59M	2	3.1	3.4	4.8	5.3	5.6	6	4.9	3.6	2.7	2	2	2.1	7.44	6.16	7.1	6.6	6.3	6.5	4.9	4.7	4.8	4.6	3.4	3
60M	2	3.5	3.4	5.28	5.28	5.81	6.56	3.52	3.52	3.21	3.21	3.2	3.14	6.81	6.81	5.88	5.88	6.53	7.24	8.5	8.5	8.5	8.5	5.27	4.32
61F	3	1.6	1.6	3.44	3.44	4.68	4.68	5.08	5.08	3.12	3.12	2.64	2.64	9.67	9.67	6.45	6.45	5.35	5.35	5.67	5.67	4.8	4.6	3.4	3
62M	3	4.16	4.16	4.8	5.03	4.02	4.02	4.24	4.24	0.39	0.39	2.6	2.6	9.5	9.58	7.22	7.22	5.41	5.41	4.8	4.8	8.5	8.5	6.3	6.3
63F	3	1.7	2.37	4.83	4.83	5.9	6.26	5.07	3.92	2.22	2.22	2.51	3.75	7.66	9.66	6.52	6.52	7.99	7.86	4.13	2.68	5.48	5.48	1.62	1.62
64M	3	2.67	2.67	5.42	5.92	7.49	7.73	6.52	6.53	5.04	5	3.02	3.02	11.52	11.52	10.78	10.22	9.95	9.4	3.57	3.57	6.91	6.62	1.62	1.62
65M	3	2.67	2.67	5.42	5.92	7.48	7.73	6.52	6.53	5.04	5	3.02	3	11.52	11.51	10.78	10.22	9.95	9.4	3.57	3.57	6.91	6.62	1.6	1.6
66M	3	2.46	2.46	4.63	4.63	6	5.49	3.32	3.22	2.99	2.99	1.11	0.7	10.39	10.2	10.2	10.2	9.57	9.58	8.07	8.07	8.07	5.58	5.58	2.75
67M	3	2.46	2.46	3.97	3.97	4.98	4.98	3.32	3.32	3.05	3.05	2.65	2.65	10.39	10.2	8.07	8.07	7.05	7.05	8.07	8.07	6	5	5	2
68F	3	2.78	2.78	5.1	6.88	7.25	7.25	6.11	6.11	6.05	3.54	1.46	1.46	10.62	10.62	9.66	9.24	8.58	8.58	0.72	0.72	2.67	3.45	6.1	6.1
69F	3	0.83	0.9	5.1	6.88	7	7.25	4.61	6.07	6.05	3.54	1.46	1.46	9.33	10.25	9.66	9.24	8.58	8.58	4.66	3.69	2.67	3.45	6.1	6.1
70M	3	0.83	0.9	6.2	6.62	7.11	6.24	4.61	6.07	1.04	1.04	1.36	0.83	9.33	10.25	9.66	9.24	8.58	8.58	4.66	3.69	2.67	3.45	6.1	6.1
71M	3	3.01	3.01	5.44	5.07	2.65	4.12	3.43	3.43	0.42	0.42	0.86	0.47	7.34	7.34	7.34	6.52	7.78	5.53	4.29	4.29	1.75	1.72	3.69	3.17
72F	3	1.67	1.88	5.08	6.46	6	6.28	6.94	5.55	3.83	2.38	1.64	1.46	11.94	10.83	8.02	8.67	8.23	8.01	7.71	6.93	7.83	7.79	6.23	6.82
73M	3	2.15	2.15	3.38	5.28	5.28	5.56	4.14	4.14	2.29	0.86	1.46	0.71	10.81	10.81	9.07	8.72	10.11	14.01	1	1	1.42	1.23	2.96	0.6
74F	3	1.6	1.6	3.44	3.44	4.68	4.68	4.14	5.08	3.12	3.12	2.64	2.64	9.67	9.67	6.45	6.45	5.35	5.35	5.67	5.67	8.5	8.8	5.27	4.32
75M	3	4.16	4.16	4.8	5.03	4.02	4.02	4.24	4.24	0.39	0.39	2.6	2.6	9.5	7.22	7.22	7.22	5.41	5.41	4.8	4.8	8.5	8.5	6.3	6.3
76F	3	1.7	2.7	4.73	4.83	5.9	6.26	5.07	3.92	2.22	2.22	2.51	3.75	7.66	9.66	6.52	6.52	7.99	7.86	4.13	2.68	5.48	5.48	1.62	1.62
77M	3	2.67	2.67	5.42	5.92	7.49	7.73	6.52	6.53	5.04	5	3.02	3	11.2	11.52	10.78	10.22	9.95	9.4	3.57	3.57	6.91	6.62	1.5	1.6
78M	3	2.67	2.67	5.42	5.92	7.49	7.73	6.52	6.53	5.04	5	3.02	3.02	11.12	11.52	10.76	10.2	9.95	9.4	3.57	3.57	6.91	6.62	1.5	1.6
79M	3	2.46	2.46	4.63	4.6	5	5.59	3.32	3.22	2.99	2.99	1.11	0.7	10.39	10.12	10.2	10.2	9.7	9.8	8.07	8.07	8.07	5.58	5.8	2.76
80F	3	2.46	2.46	3.97	3.97	4.98	4.98	3.22	3.22	2.99	2.99	2.65	2.65	10.39	10	8	8	7	7	8	8	8	5.5	5.5	3.75
81F	3	2.78	2.78	5.1	6.88	7.25	7.25	6.11	6.11	6.05	3.54	1.46	1.46	10.62	10.62	9.66	9.24	8.58	8.58	0.72	0.72	2.67	3.45	6.1	6.1
82M	3	0.83	0.9	5.1	6.88	7	7.25	4.61	6.07	6.05	3.54	1.46	1.46	9.33	10.25	9.66	9.24	8.58	8.58	4.66	3.68	2.67	3.45	6.1	6.1
83M	3	0.83	0.9	6.2	6.62	7.11	6.24	4.61	6.07	1.04	1.04	1.35	0.83	9.33	10.25	9.66	9.24	8.58	8.58	4.66	3.69	2.67	3.45	6.1	6.1
84F	3	3.01	3.01	5.44	5.07	2.65	4.12	3.43	3.43	0.42	0.42	0.86	0.47	7.34	7.34	7.34	6.52	7.78	5.53	4.28	4.29	1.75	1.72	3.69	3.17
85M	3	1.67	1.88	5.08	6.46	6	6.28	6.94	5.55	3.83	2.39	1.64	1.46	11.94	10.83	8.02	8.67	8.23	8.01	7.71	6.93	7.83	7.79	6.23	6.82
86F	3	2.15	2.15	3.38	5.28	5.28	5.56	4.14	4.14	2.29	0.86	1.46	0.71	10.81	10.81	9.07	8.72	10.11	12	1	1	1.42	1.23	2.96	0.6
87M	3	1.6	1.6	3.44	3.44	4.68	4.68	4.14	5.08	3.12	3.12	2.64	2.64	9.67	9.67	6.45	6.45	5.35	5.35	5.67	5.67	8.5	8.8	5.37	4.32
88F	3	4.16	4.16	4.8	5.05	4.03	4.02	4.24	4.24	0.39	0.39	2.6	2.6	9.5	7.22	7.22	7.22	5.41	5.41	4.8	4.8	8.5	8.5	6.3	6.3

srlnum	Group	Distance of IAC (in mm) from the BCP						Distance of IAC (in mm) from the LCP						Distance of IAC (in mm) from the Inferior BM						Distance of IAC (in mm) from the Tooth apex					
		1^{st} premolar	2^{nd} premolar	1^{st} molar mesial	1^{st} molar distal	2 nd molar mesial	2^{nd} molar distal	1^{st} premolar	2^{nd} premolar	1^{st} molar mesial	1^{st} molar distal	2 nd molar mesial	2^{nd} molar distal	1^{st} premolar	2^{nd} premolar	1^{st} molar mesial	1^{st} molar distal	2 nd molar mesial	2^{nd} molar distal	1^{st} premolar	2^{nd} premolar	1^{st} molar mesial	1^{st} molar distal	2 nd molar mesial	2^{nd} molar distal
1F	1	4.16	4.16	6.01	6.55	6.48	6.48	4.44	4.44	1.3	0.96	1.51	1.51	7.14	7.14	6.23	6.76	6	6	0.4	0.4	3.9	1.09	0	0
2F	1	3.6	3.6	4.64	6.21	6.01	5.01	5.26	5.26	2.68	1.71	1.64	2.18	6.82	6.82	4.14	4.14	5	5	3.16	3.16	6.37	4.71	4.3	3.39
3F	1	2.93	2.93	5.39	4.96	4.65	4.65	3.34	3.34	1.92	2.23	2.48	2.48	4.65	4.65	3.93	4.43	4.07	4.07	2.77	2.77	4.71	3.93	2.9	2.9
4F	1	2.92	2.92	4.5	4.57	5.94	5.94	4.98	4.68	1.57	1.09	1.09	1.09	5.26	5.36	3.78	3.57	2.98	2.98	0	0	2.24	2.46	0	0
5M	1	4.78	4.98	8.1	11.16	8	8	7.17	7	2.85	0.98	1.95	1.95	8.82	8.82	6.61	9.51	9.02	9.02	2.18	2.18	3.77	0.13	0.52	0.52
6M	1	2.94	2.94	7.17	7.1	6.82	7.03	3.55	3.55	1.92	1.37	3.34	2.6	9.17	9.17	8.36	8.46	9.86	9.8	1.67	1.67	0	0	0	0
7M	1	1.64	1.64	6.14	6.14	6.01	6.01	4.16	5.39	0.68	1.44	1.78	1.78	10.58	8.62	7.58	7.64	7	7	4.58	5.66	5.96	6.44	2.8	2.8
8F	1	6.6	2.94	3.41	4.03	4.53	4.53	4.71	2.95	3.55	2.66	2.26	2.26	7.32	5.13	4.44	3.64	3.69	3.69	5.94	8.19	4.22	3.24	2.47	2.47
9F	1	2.56	2.56	3.14	3.89	4.3	4.3	4.71	4.71	5.19	5.73	6.58	6.58	6.91	6.91	7.04	6.39	6.46	6.46	0.68	0.68	2.67	1.93	0	0
10F	1	3.82	2.93	4.23	4.3	4.03	4.03	4.1	3.96	2.59	2.46	3.2	3.2	5.94	5.19	4.72	4.12	4.19	4.19	2.4	1	1.35	0.07	0.2	0.2
11F	1	3.82	2.93	5.12	4.3	4.3	4.03	4.1	3.96	1.3	2.46	1.98	3.2	5.94	5.19	3.97	4.12	3.86	4.19	2.4	1	1.67	0.07	0.68	0.2
12F	1	1.67	2.9	4.08	5.57	6.26	6.26	3.5	2.64	2.24	1.61	1.38	1.38	8.32	5.17	4.15	4.6	4.19	4.19	3.13	4.59	4.21	3.52	0.59	0.59
13M	1	1.3	1.3	5.32	6.51	4.6	4.6	3.33	3.33	2.45	1.95	2.9	2.9	9.35	9.35	6.37	6.37	6.25	6.25	3.86	3.86	0.81	1.68	5.19	5.19
14F	1	1.92	1.92	4.09	5.32	5.32	5.66	5.33	5.33	2.94	1.77	1.77	1.71	5.94	5.93	4.03	4.94	4.94	5.45	4.04	4.04	4.01	2.94	2.94	0.35
15M	1	2.12	2.12	4.5	4.37	5.19	5.12	4.1	4.1	3.62	4.85	4.09	3.83	8.06	8.06	6.69	6.69	7.05	7.05	7.92	7.92	11.39	11.69	8.83	8.85
16F	1	2.12	2.12	6.45	6.58	7.87	7.52	4.1	4.1	2.51	3.03	2.11	2.12	8.06	8.06	7.14	7.56	8.18	7.85	7.92	7.92	2.85	2.82	0	0
17F	1	3.34	3.34	6.64	6.34	6.82	6.82	5.34	5.34	2.61	2.61	2.19	2.19	9.8	9.8	8.51	8.51	6.11	6.11	4.47	4.47	3.21	4.3	3.34	3.34
18F	1	3.6	3.6	4.64	6.21	6.01	5.01	5.26	5.26	2.68	1.71	1.64	2.18	6.82	6.82	4.14	4.14	5	5	4.47	4.47	3.21	4.3	3.34	3.34
19F	1	2.93	2.93	5.39	4.96	4.65	4.65	3.34	3.34	1.92	2.23	2.48	2.48	4.65	4.65	3.93	4.43	4.07	4.07	2.27	2.27	4.71	3.93	2.9	2.9
20F	1	3.1	3.4	4.8	5.3	5.8	6	4.9	3.6	2.7	2	2	2.1	9.2	8.4	7.1	6.6	6.3	6.5	4.9	4.7	4.8	4.6	3.4	3
21F	1	4.78	4.98	8.1	11.16	8	8	7.17	7	2.85	0.98	1.95	1.95	8.82	8.82	6.61	9.51	9.02	9.02	2.18	2.18	3.77	0.13	0.52	0.52
22F	1	2.9	3.3	5.1	5.6	6.2	6.2	4.3	3.5	2.5	2.4	2	2.1	9.3	8.3	6.9	6.6	6.7	6.8	4	4.8	4.7	4.8	2.3	2
23M	1	2.94	2.94	7.17	7.1	6.68	7.03	3.55	3.55	1.92	1.37	3.34	2.6	9.17	9.17	8.37	8.46	9.86	9.8	1.67	1.67	2	4	2.4	0.36
24M	1	1.64	1.64	6.14	6.14	6.01	6.01	4.16	5.39	0.68	1.44	1.78	1.78	10.58	8.62	7.58	7.64	7	7	4.58	5.66	5.96	6.44	2.8	2.8
25M	1	2.9	3.3	5.1	5.6	6.2	6.2	4.3	3.5	2.5	2.3	2	2.1	9.3	8.3	6.9	6.6	6.6	6.8	4.8	4.7	4.8	4.2	2.8	2.3
26F	1	6.6	2.94	3.14	3.89	4.3	4.3	4.71	2.95	3.55	2.66	2.26	2.26	7.32	5.13	4.44	3.64	3.68	3.69	5.94	8.19	4.22	4.24	2.47	2.47
27F	1	3.82	2.93	5.12	4.3	4.3	4.03	4.1	3.93	1.3	2.46	1.98	3.2	5.94	5.19	3.97	4.12	3.86	4.19	2.44	0	1.67	0.07	0.68	0.2
28F	1	3.1	3.4	4.8	5.3	5.8	6	4.9	3.6	2.7	2	2	2.1	9.4	8.4	7.1	6.6	6.3	6.5	4.9	4.7	4.8	4.6	3.4	3
29F	1	1.92	1.92	4.09	5.32	5.32	5.66	5.33	5.33	2.94	1.77	1.77	1.17	5.93	5.93	4.03	4.94	4.94	5.45	4.04	4.04	4.01	2.94	2.94	0.35
30F	1	2.12	2.12	4.5	4.37	5.19	5.12	4.1	4.1	3.62	4.85	4.09	3.83	8.06	8.06	6.69	6.69	7.09	7.05	7.92	7.92	11.39	11.69	8.83	8.85
31M	2	2.8	3.48	4.5	7.21	5.86	7.36	6.83	5.32	2.83	1.65	1.93	1.99	8.88	6.77	6.52	7.33	6.46	7.7	9.02	11.68	10.72	9.13	7.24	5.74
32M	2	4.34	4.34	7.04	7.44	8.21	8.21	5.29	5.29	3.62	2.94	1.65	1.65	8.88	6.77	9.33	9.33	8.66	8.66	4.47	4.47	2.08	3	4.33	4.33
33M	2	2.95	2.9	4.87	4.87	6.45	6.13	4.27	4.27	2.89	2.89	2.96	2.72	8.88	12.97	5.87	5.87	5.48	5.65	4.77	0.8	5	5	5.73	5.05
34M	2	2.95	2.95	4.87	4.87	6.45	6.13	4.27	3.97	2.89	2.89	2.96	2.72	8.88	12.97	5.87	5.87	5.48	5.65	4.71	0.8	5	5	5.74	5.05
35F	2	3.43	3	6.08	6.84	6.84	6.84	5.7	5.18	3.78	1.64	1.64	1.64	7.44	8.73	4.24	4.18	4.18	4.18	5.26	4.3	6.45	5.42	5.42	5.42
36F	2	3.43	3	6.08	6.84	3.09	3.28	5.7	5.18	3.78	1.64	4.35	2.88	7.44	8.73	4.24	4.18	10.65	12.04	5.26	4.3	6.45	5.42	2.77	1.26
37F	2	4.03	4.03	4.94	6.62	6.62	4.49	4.37	4.37	4.25	3.15	3.15	4.1	8.25	8.25	7.11	8.02	7.79	6.79	10.94	10.94	8.27	7.24	8.51	7.51
38M	2	2.49	2.54	3.75	4.06	5.3	4.97	4.55	3.19	1.36	1.73	1.08	1.94	10.92	9.24	8.49	8.7	7.91	8.44	3.23	3.08	4.33	2.73	0.74	0.44
39M	2	2.49	2.54	3.75	4.06	5.3	4.97	4.55	3.19	1.36	1.73	1.08	1.94	10.92	9.24	8.49	8.7	7.91	8.44	3.23	3.08	4.33	2.73	0.74	0.44
40M	2	1.78	1.78	4.79	5.91	5.7	5.7	5.05	5.05	2.74	2.74	1.08	1.94	9.02	9.02	7.45	7.45	7.91	8.44	1.96	1.96	2.53	2.53	0.74	0.44

44F	2	4.78	4.78	6.31	6.6	5.18	4.14	4.03	4.04	2.35	2.08	3.24	2.77	6.53	6.53	6.07	5.62	6.66	9.11	1.86	1.86	1.75	1.51	0	0
45F	2	3.14	3.14	3.82	5.41	5.69	5.69	4.99	4.99	3.82	3.7	3.35	3.35	6.97	6.97	5.39	5.67	7.92	7.92	3.69	3.69	5.48	5.57	0.7	0.7
46M	2	2.91	2.91	5.5	5.5	6.65	6.65	4.24	4.25	1.86	1.86	0.71	0.71	8.1	8.1	6.21	6.21	8.21	8.34	8.26	8.26	8.26	8.26	4.64	5.56
47F	2	1.61	2.74	5.34	5.34	5.89	5.89	6.08	3.36	1.3	1.3	1.81	1.81	8.84	6.01	6.29	6.29	6.03	6.03	5.46	2.7	2.32	2.38	0.48	0.48
48F	2	1.61	2.74	5.34	5.34	5.89	5.89	6.08	3.36	1.3	1.3	1.81	1.81	8.84	6.01	6.29	6.29	6.03	6.03	5.46	2.7	2.23	2.38	0.48	0.48
49F	2	3.35	3.35	6.28	6.63	7.18	7.18	5.06	5.06	3.68	2.64	1.91	1.91	6.9	6.9	4.95	5.4	4.88	4.88	2.22	2.22	3.83	2.6	1.48	1.48
50F	2	2.32	2.32	5.22	6.21	7.18	7.18	4.12	4.12	2.53	2.53	1.91	1.91	7.64	7.64	5.84	4.87	4.88	4.88	2.22	2.22	3.83	2.6	1.48	1.48
51F	2	2.25	3.58	7.6	7.6	5.8	5.8	5.53	5.96	3.21	2.55	1.58	1.58	11.41	10.25	8.75	8.75	3.51	3.51	4.4	6.68	3.04	2.17	1.45	2.03
52F	2	1.65	1.65	3.42	3.42	3.9	4.02	4.59	4.59	3.16	3.16	3.1	3.3	9.87	9.87	4.25	4.25	4	4.56	6.91	6.91	3	2	5.86	5.63
53M	2	2.87	2.87	4.87	5.3	3.9	4.02	2.06	2.06	1.36	1.37	3.1	3.3	9.02	9.02	7.7	7.06	7.92	8.4	2.01	2.01	3.62	2.47	0.74	0.44
54F	2	2.83	2.83	4.51	4.71	3.9	4.02	3.77	3.77	2.2	1.7	1.8	1.8	9.75	9.75	7.7	7.06	7.92	8.4	2.01	2.01	3	2.47	0.74	0.44
55F	2	4.03	4.03	4.27	5.81	7.24	7.58	5.88	5.88	3.84	2.4	1.52	1.03	10.03	10.03	10.1	9.68	8.73	8.64	2.01	2.01	3	2.47	0.74	0.44
56M	2	1.78	1.78	4.79	5.91	5.7	5.7	5.05	5.05	2.74	2.74	1.08	1.94	9.02	9.02	7.45	7.45	7.91	8.44	1.96	1.96	2.53	2.53	0.74	0.44
57M	2	2.9	3.3	5.1	5.6	6.2	6.2	4.3	3.5	2.5	2.3	2	2.1	9.3	8.3	6.9	6.6	6.6	6.8	4.8	4.7	4.8	4.2	2.8	2.3
58F	2	3.14	3.14	3.82	5.41	5.69	5.69	3.55	3.55	2.77	2.77	3.56	3.95	9.68	9.68	9.22	7.57	7.95	7.61	6.88	6.88	5.24	4.45	0.6	1.51
59M	2	2.9	3.3	5.1	5.6	6.2	6.2	4.3	3.5	2.5	2.3	2	2.1	9.3	8.3	6.9	6.6	6.6	6.8	4.8	4.7	4.8	4.2	2.8	2.3
60M	2	2.91	2.91	5.5	5.5	6.65	6.65	4.24	4.25	1.86	1.86	0.71	0.71	8.1	8.1	6.21	6.21	8.21	8.43	8.26	8.26	8.26	8.26	4.64	5.56
61F	3	1.6	1.6	3.44	3.44	4.68	4.68	5.08	5.98	3.12	3.12	2.64	2.64	9.67	9.67	6.45	6.45	5.35	5.35	5.67	5.67	4.55	4.55	6.3	6.3
62M	3	4.15	4.15	4.8	5.03	4.68	4.68	4.86	4.86	3.61	2.92	2.64	2.64	8.32	8.32	7.22	5.38	5.35	5.35	5.67	5.67	4.55	4.55	6.3	6.3
63F	3	1.7	2.36	4.2	4.2	6.55	6.8	5.07	3.92	3.55	3.55	1.53	2.5	7.88	7.88	8.2	8.2	6.56	6.52	4.78	4.78	4.55	4.55	2.61	1.53
64M	3	2.93	2.93	3.76	5.07	6.74	6.74	3.96	3.96	5.56	3.54	2.24	2.24	10.15	10.15	8.82	8.83	8.47	8.47	5.59	5.59	7.48	6.48	6.43	6.43
65M	3	2.93	2.93	3.76	5.07	6.74	6.74	3.96	3.96	5.56	3.54	2.24	2.24	10.15	10.15	8.82	8.83	8.47	8.47	5.59	5.59	7.48	6.48	6.43	6.43
66M	3	1.36	1.36	4.68	4.68	5.78	5.76	4.39	4.39	3.38	3.38	1.46	1.46	9.02	9.02	9.02	9.02	10.12	10.12	7.25	7.25	6	5	5	5
67M	3	1.36	1.36	3.96	3.96	4.98	4.98	4.39	4.39	3.05	3.05	2.65	2.65	9.02	9.02	8.07	8.07	7.05	7.05	7.25	7.25	6	5	5	5
68F	3	3.3	3.3	5.04	5.58	7.25	7.25	6.2	6.2	5.5	4.97	1.46	1.46	10.09	10.09	9.79	9.2	8.58	8.58	3.38	3.38	6.18	6.96	6.1	6.1
69F	3	0.84	0.9	5.04	5.58	7.25	7.25	4.61	6.07	5.5	4.97	1.46	1.46	9.33	10.25	9.79	9.2	8.58	8.58	4.66	3.68	6.19	6.96	6.1	6.1
70M	3	0.84	0.9	7.23	7.02	7.11	6.24	4.61	6.07	1.09	0.86	1.36	0.83	9.33	10.25	7.36	6.72	7.3	7.55	4.66	3.68	2.85	1.13	0.51	0
71M	3	3.01	3.01	5.15	6.57	6.99	6.99	3	3.45	3.43	2.46	0.62	0.62	7.34	7.34	7.34	6.52	5.53	5.53	4.49	4.29	8.99	9.94	1.78	1.78
72F	3	1.76	1.6	3.2	5.21	5.39	4.94	6.8	6.8	5.35	4.66	2.74	2.38	10.6	10.6	7.96	7.65	6.5	7.53	5.59	5.59	7.68	7.69	5.85	5.99
73M	3	2.72	2.72	5.18	5.28	5.28	5.56	4.14	4.14	2.19	0.86	1.46	0.71	10.81	10.81	9.07	8.72	10.11	14.01	1	1	1.42	1.27	2.96	0.6
74F	3	1.6	1.6	3.44	3.44	4.68	4.68	5.08	5.98	3.12	3.12	2.64	2.64	9.67	9.67	6.45	6.45	5.35	5.35	5.67	5.67	4.55	4.55	6.3	6.3
75M	3	4.15	4.15	4.8	5.03	4.68	4.68	4.86	4.86	3.61	2.92	2.64	2.64	8.32	8.32	7.22	5.38	5.35	5.35	5.67	5.67	4.55	4.55	6.3	6.3
76F	3	1.7	2.36	4.2	4.2	6.55	6.8	5.07	3.92	3.55	3.55	1.53	2.5	7.88	7.88	8.2	8.2	6.56	6.52	4.78	4.78	4.55	4.55	2.61	1.53
77M	3	2.93	2.93	3.76	5.07	6.74	6.74	3.96	3.96	5.56	3.54	2.24	2.24	10.15	10.15	8.82	8.83	8.47	8.47	5.59	5.59	7.46	6.48	6.43	6.43
78M	3	1.36	1.36	4.68	4.68	5.78	5.76	4.39	4.39	3.38	3.8	1.46	1.46	9.02	9.02	9.02	9.02	10.12	10.12	7.25	7.25	6	5	5	5
79M	3	1.36	1.36	4.68	4.68	5.78	5.76	4.36	4.39	3.38	3.38	1.46	1.46	9.02	9.02	9.02	9.02	10.12	10.12	7.25	7.25	6	5	5	5
80F	3	3.3	3.3	5.04	5.58	7.25	7.25	6.2	6.2	5.5	4.97	1.46	1.46	10.09	10.09	9.79	9.2	8.9	8.58	3.38	3.38	6.18	6.96	6.1	6.1
81F	3	0.84	0.9	5.04	5.58	7.25	7.25	4.61	6.07	5.5	4.97	1.46	1.46	9.66	9.66	9.79	9.2	8.58	8.58	4.66	3.68	6.19	6.96	6.1	6.1
82M	3	0.84	0.9	7.23	7.02	7.11	6.24	4.61	6.07	1.09	0.86	1.36	0.83	9.33	10.25	7.36	6.72	7.3	7.55	4.66	3.68	2.86	1.13	0.51	1
83M	3	3.01	3.01	5.15	6.47	6.99	6.99	3	3.45	3.43	2.46	0.62	0.62	7.34	7.34	7.34	6.52	5.53	5.3	4.49	4.29	8.99	9.94	1.78	1.78
84F	3	1.76	1.6	3.2	5.21	5.39	4.49	6.8	6.8	5.35	4.66	2.74	2.38	10.6	10.6	7.96	7.65	6.5	7.53	5.59	5.59	7.68	7.68	5.85	5.9
85M	3	2.72	2.27	5.18	5.28	5.28	5.56	4.14	4.14	2.18	0.86	1.46	0.71	10.81	10	9.07	8.72	10.11	12	1	1	1.42	1.27	2.96	0.6
86F	3	1.6	1.6	3.44	3.44	4.68	4.68	5.08	5.98	3.12	3.12	2.64	2.64	9.67	9.67	6.45	6.45	5.34	5.34	5.67	5.6	4.5	4.55	6.3	6.3
87M	3	4.15	4.15	4.8	5.03	4	4	4.8	4.8	3.61	2.91	2.64	2.64	8.32	8.32	7.22	5.38	5.35	5.35	5.67	5.67	4.55	4.55	2.61	1.53
88F	3	1.7	2.36	4.2	4.2	6.55	6.8	5.07	3.92	3.55	3.5	1.53	2.5	7.88	7.88	8.2	8.2	6.56	6.52	4.78	4.78	4.55	4.55	2.61	1.51

Sree Mookambika Institute of Medical Sciences
Kulasekharam (K.K District, TN) 629161
Phone No: 04651-280866, Fax No. 04651-280740

Institutional Human Ethics Committee

Registered under CDSCO with Reg No. ECR/446/Inst/TN/2013

Ref. No. SMIMS/IHEC/2015/A/15 **Date: 10th April 2015**

Certificate

This is to certify that the Research Protocol Ref. No. **SMIMS/IHEC/2015/A/15**, entitled "Evaluation of Spatial Relationship of Inferior Alveolar Canal in Three Different Age Groups Using Cone Beam Computed Tomography" submitted by Dr. M. Farakath Khan, Postgraduate of Department of Oral Medicine and Radiology, SMIDS has been approved by the Institutional Human Ethics Committee at its meeting held on 13th of March 2015.

[This Institutional Human Ethics Committee is organized and operates according to the requirements of ICH-GCP/GLP guidelines and requirements of the Amended Schedule-Y of Drugs and Cosmetics Act, 1940 and Rules 1945 of Government of India.]

SREE MOOKAMBIKA INSTITUTE OF MEDICAL SCIENCES ★ KULASEKHARAM ★
IHEC
Date.10/4/15

Dr. Rema Menon. N
Member Secretary
Institutional Human Ethics Committee
Professor of Pharmacology and HOD
SMIMS, Kulasekharam [K.K District]
Tamil Nadu -629161